DOCUMENT RESUME

ED 140 797 IR 004 846

AUTHOR Slate, Mitchell Perry
TITLE Application of a Library Network Model: A Case Study of the Rolling Prairie Library System.
PUB DATE 77
NOTE 107p.; Master's Thesis, University of Illinois at Urbana-Champaign; For related documents, see ED 101 667, ED 107 287, ED 124 179, ED 126 879, ED 134 201 ; Pages 26-28 and 53-55 will be marginally legible

EDRS PRICE MF-$0.83 HC-$6.01 Plus Postage.
DESCRIPTORS Case Studies; *Interlibrary Loans; *Library Networks; *Mathematical Models; *Policy Formation; Statistical Data; Systems Analysis; Tables (Data)
IDENTIFIERS ILLINET; Illinois Library and Information Network; *Rolling Prairie Library System

ABSTRACT

This case study applies a mathematical model to the Illinois Library and Information Network (ILLINET) Rolling Prairie Library (RPL) System. Given certain dimensions, parameters, and operating policies of a library network, the model calculates probability of satisfying a request, average processing time, average total and unit costs, and average processing loads through the network. The study describes quantitatively how RPL headquarters attempts to satisfy a request, and considers the parameter requirements of the ILLINET model and data from a 12-week sample. It analyzes present policy, focusing on the effects of changes on fill rate/processing time, and the impact of filmed card catalogs on performance. Value oriented policies are defined in terms of strength, time, and compromise, and are analyzed for effects on systems performance. The study recommends: (1) requests waiting for missing or reserved documents be held only seven days and referrals be made automatically on a specified route to decrease average processing time; and (2) the filmed card catalog be used early in the referral route to decide participating libraries and query order. Essays on suggested routing of requests, data collection, and request classifications are appended. (KP)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED140797

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

APPLICATION OF A LIBRARY NETWORK MODEL: A CASE STUDY OF THE ROLLING PRAIRIE LIBRARY SYSTEM

by

MITCHELL PERRY SLATE

This work was supported in part by the State of Illinois Inter Library Loan Network.

IR 004 948

APPLICATION OF A LIBRARY NETWORK MODEL: A CASE STUDY OF THE ROLLING PRAIRIE LIBRARY SYSTEM

BY

MITCHELL PERRY SLATE

B.S., University of Illinois, 1975

THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science in Mechanical Engineering
in the Graduate College of the
University of Illinois at Urbana-Champaign, 1977

Thesis Adviser: Professor William B. Rouse

Urbana, Illinois

ACKNOWLEDGMENTS

I would like to recognize and thank Dr. William B. Rouse and Ms. Sandra H. Rouse for their help, both technical expertise and encouragement in the construction of this document. Together, they developed the mathematical model and computer program upon which this case study is based. In addition, they provided direction and assistance throughout the months this thesis was being prepared.

Special acknowledgement and thanks should go to Mr. Ray ick Director of RPL; Mr. Paul Johnson, Supervisor of the Interlibrary Loan Department at RPL, and the entire staff of the Interlibrary Loan Department. Their friendly cooperation, suggestions, and work at collecting data made this report possible.

Special recognition should also go to Ms. Maureen Wolke, undergraduate in Mathematics and Computer Science at the University of Illinois. She entered 144,738 pieces of raw data onto data files in the computer.

TABLE OF CONTENTS

CHAPTER Page

1. INTRODUCTION AND SUMMARY..... 1

2. DESCRIPTION OF ROLLING PRAIRIE LIBRARIES..... 5

3. DATA COLLECTION AND MANIPULATION..... 16

3.1 Introduction..... 16
3.2 Required Data Files..... 16
3.3 Data Collection..... 18
3.4 Data Aggregation..... 20
3.5 Formation of Data Files..... 41
3.6 Other Manipulations of Interest..... 51

4. POLICY FORMULATION AND ANALYSIS..... 56

4.1 Introduction..... 56
4.2 Analysis of RPL's Present Policy..... 56
4.3 Intuitively Reasonable Policies..... 59
4.4 Value Oriented Policies..... 65
4.5 Recommendations..... 72

REFERENCES..... 77

APPENDIX 1. SUGGESTED ROUTING OF REQUESTS..... 78

APPENDIX 2. DATA COLLECTION PERIOD..... 82

APPENDIX 3. CLASSIFICATION OF REQUESTS..... 87

LIST OF TABLES

TABLE		Page
1	REASONS A REQUEST MIGHT BE CANCELLED - REASONS A REQUEST MIGHT BE RECLASSIFIED	8
2	MODES OF DOCUMENT DELIVERY	11
3	MODES OF REQUEST ROUTING	13
4	INFORMATION AVAILABLE FOR EACH REQUEST	15
5	LOCATION CODES	19
6	REQUEST CLASSIFICATION CODES AND OTHER CODES	21
7A	THE ORIGIN AND CLASS OF INCOMING REQUESTS	23
7B	THE ORIGIN AND CLASS OF INCOMING REQUESTS	24
8	RESOURCE LIBRARY UTILIZATION AND PERFORMANCE	26
9	THE VAN DELIVERY SCHEDULE EMPLOYED BY RPL	30
10	AGGREGATION OF REQUESTING LIBRARIES	31
11	AGGREGATION OF RESOURCE LIBRARIES	33
12	AGGREGATION OF REQUEST CLASSES	35
13	CALCULATION OF 95% CONFIDENCE LIMITS	37
14	THE ORIGIN AND CLASS OF INCOMING REQUESTS	38
15A	RESOURCE LIBRARY UTILIZATION AND PERFORMANCE	39
15B	AVERAGE PROCESSING TIMES FOR EACH RESOURCE LIBRARY	40
16	THE AVERAGE DOCUMENT DELIVERY TIME TO ALL REQUESTING LIBRARIES FOR REQUESTS FILLED AT ALL BUT RESOURCE LIBRARY 7	49
17	PROCESSING COSTS PER REQUEST FOR THE R AND R CENTERS	50
18	PROCESSING COSTS PER REQUEST FOR ALL RESOURCE LIBRARIES	50

LIST OF TABLES (Con't.)

TABLE		Page
19	THE AVERAGE PROCESSING TIMES IN DAYS FOR EACH RESOURCE LIBRARY	52
20	RPL'S PRESENT POLICY	57
21	RESULT OF HOLDING A REQUEST AT RPL FOR A MAXIMUM OF 7 DAYS	61
22	RPL'S PRESENT POLICY WITH HOLDING REQUEST FOR ONLY ONE WEEK	62
23	POLICY USING FILMED CATALOGS	64
24	STRENGTH POLICY	66
25	TIME POLICY	69
26	COMPROMISE POLICY	71
27	RECOMMENDED POLICY	75
28	THE PREDICTED PERCENT OF REQUESTS COMPLETED AS A FUNCTION OF THE NUMBER OF DAYS AFTER THE SAMPLING PERIOD ENDS	85

LIST OF FIGURES

FIGURE		Page
1	Flow Diagram of RPL	6
2	Model of a Resource Library	42
3	Turn Around Time for All Requests	53
4	Turn Around Time for Satisfied Requests	54
5	Turn Around Time for Cancelled Requests	55
6	Comparison of Model with Four Weeks of RPL Data	86

CHAPTER 1

INTRODUCTION AND SUMMARY

The purpose of this thesis is to discuss a case study of the Illinois Library and Information Network at the System level. The Rolling Prairie Library System headquartered in Decatur, Illinois was chosen for this study. The analyses performed here are based on a mathematical model of the Illinois Library and Information Network (ILLINET) which was developed in the reports referenced in this thesis. Hopefully, this report will aid RPL while also serving as a guide for subsequent applications of the mathematical model to other library systems.

Before summarizing the contents of this report, let us briefly review the mathematical model. (The reader should consult references 1 through 5 for a detailed discussion of the model.) Given the dimensions, parameters, and operating policies of a library network, the model will calculate the probability of satisfying a request, the average delay from initiation of a request until the receipt of the document by the requesting library, the average total and unit costs, and the average processing loads throughout the network. The dimensions required by the model are defined as the number of requesting libraries, resource libraries, and request classes. Parameters which must be provided to the model include the demand generated by requesting libraries, and the probabilities of success, processing times, and delivery times associated with the resource libraries. Network operating policies which define the paths for routing requests and document delivery must also

be provided to the model. The model's output or predictions are broken down by request class and resource library as well as being summarized across request classes and resource libraries.

Chapter 2 of this report describes qualitatively and in detail how RPL headquarters in Decatur attempts to satisfy a request. The standard operating procedures, the decision algorithms, and modes of request and document movement are presented.

Chapter 3 considers the parameter requirements of the ILLINET computer program and the data available from the Rolling Prairie Library System. Five data files are required by the computer model. These files contain the average yearly network demand, the resource library probabilities of success, average processing times, average document delivery times, and request processing costs.

A twelve week data sample was collected, keeping the number of locations and request classes as large as practical. This raw data was manipulated into preliminary tables for visual inspection. These preliminary tables illustrated the demand placed on and the performance of the Network represented as 72 requesting libraries, 72 resource libraries, and 26 request classes. Referring to these tables, the requesting libraries, resource libraries and request classes were aggregated to number 12, 8, and 13, respectively. With the raw data compiled to reflect these aggregations, the calculations necessary to form the required data files could be performed with greater statistical confidence. In addition to yielding the data tables, the calculations also provided us with RPL's actual performance over the 12 week sampling period: an 86.9 percent fill rate, with an average request processing time of 18.81 days.

The formulation of operating policies and the analysis of the system using the ILLINET computer program are discussed in the fourth chapter. RPL's present request routing policy was first entered to confirm that calculations made by the computer program were comparable with RPL's actual performance. Then, other policies were formulated to show their effect on network performance. It was not possible to determine an optimal policy, for "optimal", in terms of the best trade-off between network fill rate, average processing time, and average costs has not yet been defined for the RPL System in a numerical sense. As a consequence, several intuitively reasonable policies were analyzed. In addition, a method for determining the optimal routing policy was demonstrated (assuming that the aforementioned trade-off had been defined) by calculating "values" for each resource library in each request class in accordance with the defined optimal tradeoff. The "optimal" policy was formed by ordering the resource libraries in each request class from high to low "value".

In the last part of Chapter 4 several recommendations are made suggesting changes in operating practices at RPL headquarters, and suggesting the temporary adoption of a routing policy that queries a large number of resource libraries in a short period of time. Changes to operating practices include setting a maximum time of seven days that requests be allowed to sit waiting for a reserved or lost document instead of the present practice of allowing four weeks or more, and also allowing referrals to be made automatically instead of the present practice of handling the request between

referrals. The suggested request routing policy specifies searching the now filmed card catalogs of the Research and Reference Centers before any referrals are made. Utilizing the suggested changes and the suggested policy, RPL could maintain their high fill rate and shorten the average network processing time while quickly determining the relative values of the resource libraries in each request class. When this determination is made, RPL can alter the routing policy to relfect operating objectives.

Appendix 1 is the decision algorithm presently used by RPL in determining which resource library to query. Appendix 2 discusses determining the length of time one should allow for requests still being processed at the end of the data collection period to complete processing. The procedure utilized by a professional librarian who placed the requests in request classes is contained in Appendix 3.

CHAPTER 2

DESCRIPTION OF ROLLING PRAIRIE LIBRARIES

Rolling Prairie Libraries (RPL) is one of the 18 Systems in the Illinois Library and Information Network (ILLINET). It is headquartered at Decatur, Illinois. The purpose of RPL is to provide, for a specific number of member libraries, a communication and document delivery network so that library resources can be shared. RPL headquarters has access to the resources in its own stacks, at the member libraries of the RPL System, at the ILLINET Research and Reference Centers, and at other libraries. RPL serves 42 member public libraries (including 11 bookmobile stops), 9 academic affiliate libraries and 8 special affiliate libraries in a 12 county area. In addition, 27 school libraries (elementary and high school) have been added to the service list in a pilot program to investigate the feasibility of serving these types of libraries. If practical, the RPL network will be enlarged to handle on the order of 75 additional school libraries.

The next paragraphs will describe in detail how RPL headquarters attempts to satisfy a request from a member library. First, a flow diagram showing the present operation procedure will be presented. Discussions will then follow explaining, as necessary, the individual blocks of the diagram. Last, a list of performance data kept by RPL will be given.

The flow diagram for RPL's operations is shown in Figure 1. Two types of blocks, rectangles and diamonds, are shown. A rectangle represents any activity that takes time to complete. A simple decision (which might also take time) is depicted by a diamond. This chart is not intended to show

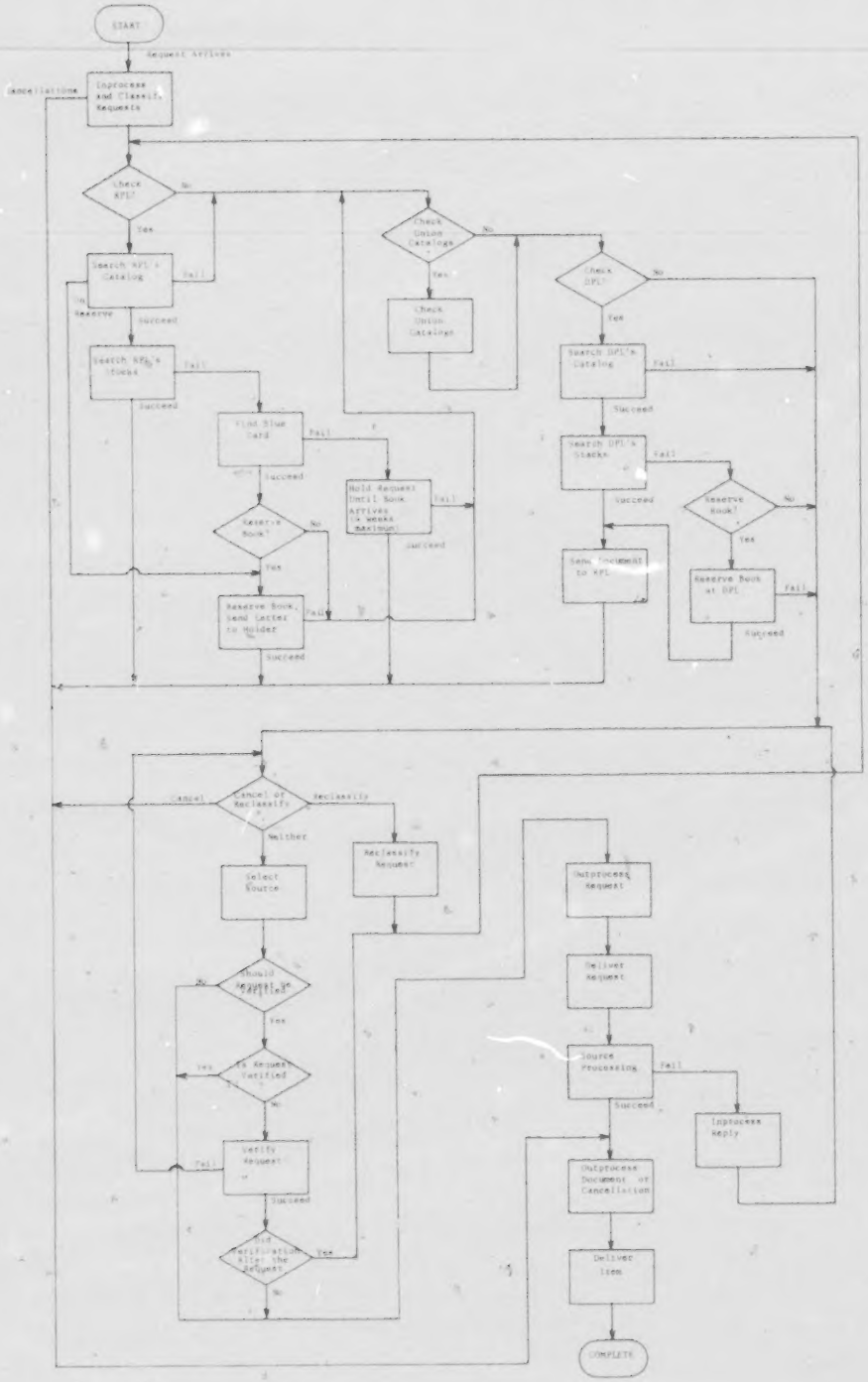


Figure 1. Flow Diagram of RPL

how every single request is handled. Such a diagram would be of awesome complexity. However, a vast majority, more than 90 percent, are adequately represented by the flow chart.

To best describe the operation of RPL headquarters, the chart can be inspected in four sections: upper left, upper right, lower left, and lower right.

In the upper left hand page RPL's resources are used. Requests arrive and are placed on the supervisor's desk. The supervisor will inprocess a batch of requests each day. (Note: in all following paragraphs, it will be assumed that requests are handled in batches.) A batch may consist of mail deliveries, the previous day's van deliveries, and any phone call requests taken since the last inprocessing.

Inprocessing consists of dating each request slip, tallying it, and sending it to the proper place. Each request is tallied so as to reflect its origin and class. If the class is a title or a simple subject, the request is processed in the Interlibrary Loan Department (ILL) of RPL. For reference requests, which are handled in a manner similar to the ILL's process, the ILL Department often seeks the assistance of other members of the professional staff at RPL. Some requests may be cancelled at the inprocessing stage because they are incomplete, paperback, or for some other reason. See Table 1 for a list of reasons.

At the next block, a decision block, the supervisor decides whether or not to check RPL's resources. Virtually all requests are searched at RPL. The only exceptions are most periodical and highly academic titles. (A fact worth mentioning is that over 50 percent of the requests received

TABLE 1

REASONS A REQUEST MIGHT BE CANCELLED

Could Not Verify

Could Not Locate

Could Not Locate by Time Needed

Ephemeral, Paperback Request

Noncirculating Where Located

Cancelled by Requesting Library

REASONS A REQUEST MIGHT BE RECLASSIFIED

Member Library or Patron Made Error in Making Out the Request

A Simple Subject Request Might Not be So Simple

by RPL are satisfied from the books kept in the headquarters.) First, RPL's card catalog is referenced to see if a title (document) is owned or on order. If it is owned, the librarian will search the stacks. Success in finding a document results in outprocessing it to the requestor. (Outprocessing will be discussed later.) If the book is on order, it will be reserved for the patron.

If the librarian searches the stacks and cannot find the document, he/she trys to determine its whereabouts. The circulation file is checked. If a circulation record is found, then the book has been checked out to another library. At this point the supervisor decides whether or not to reserve the document and attempt to retrieve it for the requestor. Such an attempt is accomplished by writing a letter to the member library in possession of the document, and requesting its return. If no circulation record is found, the document is either lost, or out on the bookmobile. In this case, RPL will hold the request until the book returns or a maximum of four weeks.

For requests not searched or not satisfied at RPL, a decision is made whether or not to check the Union Catalogs. RPL has in its possession lists of periodicals and holdings of some specialized libraries. Checking these lists may help in deciding where next to inquire.

The source next most often referred to is Decatur Public Library (DPL), which is represented in the upper right hand portion of the chart. Because of its proximity, an RPL employee walks daily to DPL to check the card catalog, serial listing, and stacks in much the same way as is done at RPL. When a title is found, it is checked out, or photocopied in the case of a

periodical article (DPL has a very large collection of periodicals), and is set aside to be shuttled back to RPL for subsequent outprocessing.

Requests hitherto unsatisfied travel now to the lower left part of the flow chart. At the first decision block requests may be cancelled, reclassified, or left unchanged. A request may be cancelled because time has run out or for some other reason. See Table 1. Reclassification can occur for reasons shown in the same table.

For unchanged requests, the supervisor selects a source to query. Most simple subject and fiction title requests are searched in the RPL System. There are restrictions as to where one may send a juvenile request. An algorithm for the selection of a source was written by Paul Johnson, supervisor of the ILL Department, and is included (Appendix 1). Table 2 is a list of sources.

Most of the requests that arrive at RPL are unverified. A decision must be made whether or not a request should be verified before it is sent to the selected source. Usually, requests that are to be routed to a source within the System are not verified by RPL. However, very rarely does a request go outside the RPL System unverified. Verification for a title or a periodical request is accomplished by finding the document in any catalog (say, at DPL, or Illinois State Library (ISL)), in Books in Print, Cumulative Book Index, in a serial listing, or with some other verification tool. A subject or reference request is verified by clarifying the question. Usually, the patron (requestor) will be contacted to verify a subject or reference request.

TABLE 2

MODES OF DOCUMENT DELIVERY

Source	Mode	Destination
RPL	Van*	Member Libraries
	Bookmobile	Bookmobile Stop
	Mail**	Affiliate Libraries
	Mail, Van	Other Systems
DPL	Shuttle	RPL
LL	Van	RPL
SIU	Mail	RPL
ISL	Mail	Member Library
	Van	RPL
UI	Van through LT	RPL
CPL	Mail	RPL
LT	Van	RPL
IVLS	Mail	RPL
Shawnee LS	Mail	RPL
Lewis & Clark LS	Mail	RPL
Kaskaskia LS	Mail	RPL
Concordia	Mail	RPL
Lincoln Christian	Mail	RPL
Millikan State	Shuttle	RPL
Sangamon State	Mail	RPL
SIU Medicine	Mail	RPL
Richland Community College	Shuttle	RPL
AE Staley	Shuttle	RPL
Adolph Meyer	Shuttle	RPL
Archer Daniels	Shuttle	RPL
University of Chicago	Mail	RPL
Northwestern University	Mail	RPL
John Crerar	Mail	RPL
ISHS	Mail	RPL
CBFA	Mail	RPL
Moweaqua	Van	RPL

* Documents will be mailed, if the request is "urgent"

**RPL will notify in-town libraries by phone that document awaits pickup.

Often times, a request cannot be verified, at which time it may be cancelled. Also, a request can be altered (from fiction to nonfiction, or from subject to reference, for example) while it is being verified. In this case, it might be desirable to check earlier sources and/or reclassify the request.

With all of the above accomplished, the request is outprocessed. (Refer to the lower right hand portion of the flow diagram.) The request slip is dated opposite the source to be queried and is set aside to be teletyped (TWX'd), mailed, or sent by van to that source. See Table 3 for request delivery modes.

Any source will process a title or periodical request and send either the document or the unsatisfied request back to RPL (with the reason for not satisfying), with the exception of ISL. ISL sends documents directly to the requesting library. Reference requests handled at the Center level are referred automatically to other Research and Reference Centers until they are satisfied. (RPL boasts a 100 percent fill rate for properly filled out reference requests.) Unsatisfied requests are inprocessed by marking the appropriate box on the request slip and returning the slip to the supervisor for further consideration. The documents received by RPL are outprocessed to the requestor.

All documents, cancellation notices, and other notices are outprocessed by dating and filing the request slip, or blue card from the book jacket in the case of a request that is satisfied from RPL's collection, tallying the successes as to turn around time, origin of request, and class, and setting the item aside to be delivered (by mail or van) to the requesting library. Modes of document and request delivery are shown in Tables 2 and 3.

TABLE 3

MODES OF REQUEST ROUTING

Request Sender	Inquiry Mode	Source	Answer Mode*
Member Libraries	Van, Mail, Phone	RPL	Van
Bookmobile Stops	Bookmobile	RPL	Mail
Affiliate Libraries	Mail, Phone	RPL	Mail
Other Systems	Mail, Van	RPL	Mail, Van
RPL	Foot	DPL	Foot
	Van	LL	Mail, Van, Phone
	TWX	SIU	TWX
	Van, Mail, TWX	ISL	Mail
	TWX	UI	TWX
	TWX	CPL	TWX
	TWX, Van	LT	Van
	Mail	IVLS	Mail
	Mail	Shawnee L.S.	Mail
	Mail	Lewis & Clark L.S.	Mail
	Mail	Kaskaskia L.S.	Mail
	Mail	Concordia	Mail
	Mail	Lincoln Christian	Mail
	Phone	Millikan State	Phone
	TWX	Sangamon State	TWX
	TWX	SIU Medicine	TWX, Mail
	Phone	Richland Comm. Col.	Phone
	Phone	AE Staley	Phone, Shuttle
	Phone	Adolph Meyer	Phone, Shuttle
	Phone	Archer Daniels	Phone, Shuttle
	Request thru UI	Univ. of Chicago	Mail
	Request thru UI	Northwestern Univ.	Mail
	Request thru UI	John Crerar	Mail
	Mail	ISHS	Mail
	Mail	CBFA	Mail
	Van	Moweaqua	Mail, Phone

*Usually for unsatisfied requests. Successful replies are usually in the form of a document delivery.

RPL, in the course of its normal operations, collects and compiles data on its activity and performance levels. This data is in the form of filed requests, tally sheets, and teletype printout. A more specific list is provided by Table 4.

TABLE 4

INFORMATION AVAILABLE FOR EACH REQUEST

1. The requesting library.
2. The date the request was made.
3. The class of the request.
4. The date that RPL received the request.
5. Whether or not the request arrived verified.
6. Whether or not RPL verified the request.
7-42. For each of 9 possible resource libraries* checked:
   The source checked.
   The query date.
   The reply date.
   The result of the query.
43. The outprocessing date.

*Note: See Table 11 for a listing of these libraries.

CHAPTER 3

DATA COLLECTION AND MANIPULATION

3.1 Introduction

Information required by the computer program is of two types: data and request routing policies. The former is that information which describes the parameters of the network under evaluation: demands, resources, processing and delivery times and reimbursement policies. The latter is entered into the program to specify how a request is to be treated, that is, the order in which the resource libraries will be queried. Policies will be covered in the next chapter. The first part of this chapter will describe the data files required by the ILLINET Model. Subsequent parts will discuss the formation of these files for the RPL System: the raw data collected in Decatur, the manipulation and formation of preliminary tables, and finally, aggregation into the needed tables.

3.2 Required Data Files

The computer model draws the necessary data from five disk files. These files are entitled: DEMAND, SRVTIM, SUBFIL, DELTIM, and COSTS. (See Project Report No. 3, pp. 4-8, for more discussion on these data tables than will be presented here. Ref. 3.)

The DEMAND file is a two dimensional array containing the average number of requests per unit time period that are generated in each class by each member library (or set of member libraries). A request class may associate the request with a subject area (such as history, science, or fiction), with the type of requestor (e.g. young adult, child), or the type of document (e.g. pamphlet, periodical, book).

SRVTIM is an acronym for service times. Two types of information are contained in this file: the first is the average processing time (waiting plus being served) per request at each of the processing nodes within each resource library, and the second is the average service rate per request at each of the processing nodes within each resource library. The service rate is the average number of requests that can be serviced per unit time. This parameter is used in queueing analyses. Unfortunately, it is quite often the case that service rates cannot be estimated without costly data collection procedures. In such a situation, the queueing effects in the network may have to be ignored.

The number of processing nodes within each resource library can and does vary. Just as important, in many cases the data collected does not allow the user to determine the processing times at each node in each resource library. This occurs when, for example, the data consists of only a query date and a reply date. Then, it may only be possible to determine the overall processing times. This will be discussed further when the data for the Rolling Prairie Library System is presented and manipulated.

Closely associated with the SRVTIM file is the SUBFIL file. The parameters listed in this file represent the probabilities associated with the processing nodes of a resource library. For example, the probability of a desired document being owned and the probability of an owned document being available are included here. Six of these probabilities are specified in the SUBFIL file for every resource library. Again, as the data reduction is discussed, the SUBFIL file will be explained in more detail.

The last two files, DELTIM and COSTS, are straightforward. DELTIM contains the average delivery times between resource and requesting libraries, COSTS specifies the costs per searched request, and the cost per filled request for each of the resource libraries.

3.3 Data Collection

As stated in Chapter 2, the data available from RPL is in the form of request slips from the requesting libraries, tally sheets, and TWX messages to and from the headquarters. Of the three, request slips and TWX messages contain all of the available information; tally sheets are compiled from the request slips. Therefore, the information in the tally sheets is not employed in the analyses discussed here.

Twelve weeks of data were collected, starting with those requests inprocessed on 14 June 1976, and ending 5 September 1976. Naturally, the data collection period extended beyond September 5th to enable us to obtain all the requests inprocessed in the period of interest. (Appendix 2 discusses the problem of determining the length of time that one should allow for requests still being processed at the end of the period to be completed.) Sample size was 3366 requests, 100 percent of the workload for RPL during those weeks. Potentially, 43 pieces of data are associated with each request (see Table 4). As with most operations that handle a high volume, however, an occasional date or other piece will go by unrecorded, and be lost. Fortunately, the incidence of this is surprisingly quite low.

Every location dealing with RPL was given a two digit number (see Table 5). In addition, each request was classified with a four digit, three

TABLE 5

LOCATION CODES

01	Adolph Meyer	19	Greenup	37	Neoga	55	SIU MED
02	A. E. Staley	20	Harristown	38	Niantic	56	RPL
03	ADM (Archer Daniels)	21	Herrick	39	Oreana	57	LTLS
04	Argenta	22	Illiopolis	40	Pana	58	IVLS
05	Assumption	23	Lincoln Public Library	41	Pawnee	59	Kaskaskia
06	Atwood	24	Lincoln Christian Coll.	42	Petersburg	60	Shawnee
07	Bethany	25	Lincoln College	43	Richland Comm. Coll.	61	Lewis and Clark
08	Blue Mound	26	Lincoln Land Comm Coll.	44	Sangamon St. Univ.	62	GSA, Fed.Archiv.
09	Cerro Gordo	27	LL, Lincoln Lib, Sprgfld.	45	Shelbyville	63	IL St.Hist. Lib.
10	Clinton	28	Lovington	46	Springfield Coll. in IL	64	SIU
11	Concordia Seminary	29	Macon	47	Stonington	65	ISU
12	Cowden	30	Maroa	48	Sullivan	66	ISL
13	Decatur Memorial Hosp.	31	Mason City	49	Taylorville	67	UI
14	DPL, Decatur Public Lib.	32	Millikin University	50	Toledo	68	CPL
15	Divernon	33	Morrisonville	51	Warrensburg	69	John Crerar
16	Effingham	34	Mount Pulaski	52	Weldon	70	Northwestern
17	Elwin	35	Mount Zion	53	Williamsville	71	UC
18	Findlay	36	Moweaqua	54	Windsor	72	Other

part number. The three parts pertain to the subject matter of the requested document, the way RPL classifies requests, and a "confidence factor" showing the certainty of the classification assigned to the request. The classification procedure utilized by the professional librarian who classified the requests is included in Appendix 3. Table 6 shows the details of the classification scheme. As many subject categories were constructed as possible (leaving open the option to aggregate classes later). In addition, of the 3366 requests used, only 96 (2.9 percent) have the number "x25y": "Other, or Don't Know". Also, 347 (10.3 percent) were classified "1xyz" indicating that the librarian was only reasonably confident of her assessment while 8 (0.2 percent) were classified "2xyz": indicating that she was only guessing.

All information on each request was entered into raw data files. Coded data was entered by executing a Fortran program which accepted all pertinent locations, dates (which were converted to Julian days: 1-366), the request class, results, etc., and recorded them on disk files.

3.4 Data Aggregation

It is quite possible that the ILLINET program could be successfully run with the number of classes and locations noted above (Tables 5 and 6). On the other hand, if request classes and/or locations could be aggregated without important loss of specificity, the model would produce predictions of higher statistical quality (Ref. 5). Thus, we will now consider aggregations of requesting libraries, resource libraries, and request classes.

TABLE 6

REQUEST CLASSIFICATION CODES AND OTHER CODES

CLASS CODE "WXYZ"

W- CONFIDENCE FACTOR
0- Very Confident
1- Reasonably Confident
2- Just Guessing

XY- SUBJECT MATTER
01- Travelling
02- Newspapers
03- Music
04- Biography
05- Health
06- Education
07- Society and Culture
08- Religion
09- History
10- Political Science
11- Census
12- Athletics, Sports
13- Fiction
14- Geneology
15- Hobbies, Crafts, Pets
16- Repair, Maintenance Manuals
17- Food Science
18- Encyclopedia, Reference Books
19- Other Non-Fiction
20- Business, Math
21- Physical Sciences, Agriculture, Medicine
22- Social Sciences
23- Engineering, Technology
24- Libraries
25- Other, or Do Not Know
26- Language, Grammar

Z- RPL'S CLASSIFICATION
1- Juvenile Title Request
2- Juvenile Subject Request
3- Juvenile Reference Request
4- Adult Title
5- Adult Subject
6- Adult Reference
7- Periodical
8- Audio: Records and Cassettes

OTHER CODES

RESULT OF QUERY

0- Document Not Owned
1- Owned but Not Available
2- Owned and Sent

21

Frequency tables of the coded data were constructed for the requesting libraries and the resource libraries, and are shown in Tables 7A, 7B, and 8.

Table 7A shows the total demand from all requesting libraries in each class using the "1 to 26" classification scheme. Table 7B shows the same using the "1 to 8" scheme. Note that not all libraries are listed. Those not included did not generate any requests. This is not unusual, for many of the member libraries serve very small communities. Also, the large universities do not generate requests that RPL can handle. The total from each library is in the right hand column. Totals in each class are in the bottom row. Note in the entries for RPL in Table 7B that 80 percent of the requests are in class 4, "Adult Title". This one class is so embracing as to make RPL's classification scheme of little use for analysis with the ILLINET model. Thus, we will only employ the "1 to 26" classification scheme (Table 7A).

Table 8 shows the utilization of the 72 locations as resource libraries. For each location listed, the total number of queries made in each class, the percent of these queries satisfied, and the percent of these queries that sought documents that were owned but unavailable. Totals for each library and for each class are shown in the right hand column and the bottom rows, respectively. Note that many locations are not listed because they were not contacted or were contacted only a very few items. Indeed, only a few of the locations were contacted as resource libraries enough times to provide statistically reliable calculations of collection strengths.

With regard to Table 8, we want to define exactly the meaning of the terms filled or satisfied, and unavailable. A request is considered to have been filled or satisfied if a document meeting the specifications of the

TABLE 7A

THE ORIGIN AND CLASS OF INCOMING REQUESTS

REQUESTING LIBRARY	SUBJECT AREA REQUEST CLASSES																									TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	1	0	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	1	2	3	2	1	0	1	0	0	0	26	0	1	0	1	1	0	1	0	0	0	0	0	0	55
4	0	0	3	2	3	2	1	0	0	0	0	0	13	0	7	0	0	1	0	1	0	0	0	0	0	0	27
5	1	0	0	0	0	1	1	0	1	1	0	2	13	2	12	0	0	1	1	0	1	1	0	0	0	2	55
6	0	0	1	3	1	5	2	0	1	1	0	2	15	0	3	0	0	1	2	0	0	1	0	0	1	0	33
7	0	0	0	3	0	1	3	0	2	0	0	1	15	0	3	0	0	1	2	0	4	1	0	0	1	0	80
8	0	0	2	11	0	0	8	0	2	4	0	2	32	0	9	1	0	1	2	0	4	1	0	0	1	0	128
9	1	0	0	6	0	5	7	0	3	8	0	1	51	0	10	3	0	6	2	0	3	1	0	0	1	0	108
10	5	0	2	4	1	11	9	2	4	2	12	0	35	18	12	0	0	2	4	1	3	3	0	0	3	0	128
11	1	0	2	4	1	1	4	2	1	0	0	2	19	0	3	0	0	1	0	0	0	0	0	0	0	0	33
12	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
13	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
14	2	60	2	22	5	15	21	4	16	3	18	4	107	45	18	0	6	6	10	7	7	4	3	12	12	0	389
15	1	0	0	2	0	0	2	0	0	0	0	2	14	0	4	0	0	1	0	0	2	0	0	0	1	0	34
16	3	1	0	4	2	4	8	3	3	2	0	2	25	1	16	5	0	5	4	0	10	1	4	3	3	1	117
17	1	0	1	2	1	0	1	0	0	1	0	2	19	0	6	2	0	1	0	0	1	0	0	0	0	0	38
18	0	0	5	2	0	2	0	0	2	1	0	0	6	0	2	0	0	1	0	0	0	0	0	0	0	0	21
19	0	0	5	2	0	2	0	0	2	1	0	0	6	0	3	4	0	1	11	0	1	0	0	1	1	1	50
1	10	0	0	3	0	2	3	1	3	0	0	3	5	0	0	0	0	0	0	0	0	0	0	0	1	0	31
2	0	0	0	5	0	2	2	0	1	1	0	1	18	0	0	0	0	1	0	0	0	0	0	0	2	0	39
3	0	0	0	2	1	1	4	0	0	0	0	0	19	0	9	0	0	1	2	0	1	0	0	0	2	1	76
21	1	0	0	4	2	4	5	1	0	1	0	4	27	0	10	0	0	1	2	0	1	0	0	0	3	0	117
23	2	0	3	18	2	22	26	1	6	14	0	7	38	3	13	3	2	4	6	3	1	14	4	0	5	0	217
24	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
25	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
27	11	0	3	17	12	17	29	4	8	10	1	4	44	3	30	2	2	7	14	17	5	7	1	3	13	1	273
28	1	0	0	3	0	1	1	0	2	1	0	0	8	0	4	0	0	2	0	0	1	0	0	0	0	0	27
29	2	0	0	8	0	1	11	0	0	4	0	3	51	0	6	0	0	1	0	0	1	0	0	0	0	0	88
31	1	0	0	0	1	4	1	0	0	0	0	1	9	0	12	0	0	1	0	0	2	0	0	0	3	0	35
32	1	0	0	0	0	0	0	0	0	0	0	0	8	0	4	0	24	0	0	0	1	0	2	0	0	1	51
33	1	0	0	3	0	5	2	0	0	3	1	0	1	1	3	0	0	1	3	1	1	0	0	0	2	0	23
34	0	1	0	0	0	2	0	0	3	1	0	1	0	1	3	0	0	1	3	1	1	0	0	0	3	0	57
35	0	0	2	2	2	8	5	0	2	2	0	1	11	0	9	2	0	0	3	0	4	1	0	0	3	0	42
36	0	0	0	5	2	1	1	0	2	1	0	0	20	0	4	1	0	0	1	0	1	0	1	0	1	0	80
37	11	0	0	2	2	3	2	0	1	0	0	2	47	0	3	0	0	0	1	5	0	0	0	0	0	0	42
38	0	0	0	1	0	0	1	1	1	0	0	1	20	2	8	0	0	1	1	0	5	0	0	0	4	0	110
39	1	0	0	1	2	1	0	0	3	1	1	3	33	1	9	4	0	0	4	0	3	1	0	0	0	0	26
41	1	0	0	1	7	2	1	0	1	0	0	2	6	0	8	0	0	0	2	0	0	0	0	0	1	0	61
42	1	0	0	1	1	0	0	0	3	1	0	2	22	0	17	1	0	1	2	0	0	0	0	0	0	0	61
43	1	0	0	1	6	0	1	0	1	0	0	1	26	0	11	2	0	2	1	4	4	0	0	1	2	2	101
44	1	0	0	2	8	0	4	15	0	8	1	0	2	0	1	0	0	2	0	0	0	0	0	0	0	0	19
45	0	0	0	4	2	2	2	1	0	0	0	1	6	0	1	0	0	2	0	0	0	0	0	0	0	0	147
46	21	0	0	5	3	4	9	0	1	2	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	11
47	0	0	0	3	0	1	1	0	2	3	0	5	52	0	22	1	0	2	2	0	2	1	1	0	6	1	158
48	2	0	10	6	8	12	7	2	4	3	1	3	47	2	24	1	0	7	3	0	3	9	1	0	2	1	1
49	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	102
51	1	0	0	8	2	8	5	0	2	2	0	6	39	0	19	1	0	3	1	0	0	0	1	0	4	0	24
52	0	0	0	2	1	3	6	0	0	1	0	0	1	4	2	0	0	0	0	0	0	0	0	0	2	0	55
53	6	0	0	1	3	3	2	1	0	0	0	0	20	0	12	0	0	0	2	1	0	0	1	0	3	0	24
54	0	0	0	4	0	3	3	1	0	1	0	0	2	2	5	0	1	0	0	0	1	0	0	0	2	0	40
55	0	0	0	1	0	0	1	1	2	0	0	1	13	0	4	1	0	1	1	0	0	0	0	0	1	1	8
57	0	0	0	1	0	0	1	0	0	0	0	0	0	0	6	0	0	1	0	0	0	0	0	0	0	0	62
58	0	0	0	0	0	0	1	0	0	0	0	0	31	0	4	0	0	2	1	0	0	0	0	0	1	0	60
59	1	0	0	2	0	1	1	0	1	0	0	0	34	1	4	1	0	1	0	0	3	0	2	0	1	0	3
61	0	0	0	0	1	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	51
62	0	0	0	0	1	1	3	0	0	0	0	3	12	1	0	0	0	0	0	0	0	0	0	0	1	0	6
63	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	8
64	0	0	0	0	0	0	0	0	0	0	0	0	5	0	2	0	0	0	1	0	0	0	0	0	0	0	8
65	0	0	0	0	0	0	0	0	0	0	0	0	14	0	5	0	0	0	2	2	0	3	1	0	0	0	36
TOTAL	80	82	52	214	82	142	243	22	100	77	34	88	1118	66	387	32	35	75	90	43	82	52	22	25	96	17	3366

TABLE 7B

THE ORIGIN AND CLASS OF INCOMING REQUESTS

Requesting Library	RPL's Request Classes								
	1	2	3	4	5	6	7	8	TOTAL
1	0	0	0	1	0	0	0	0	1
4	0	0	0	52	1	0	0	2	55
5	2	0	0	17	6	0	0	0	25
6	1	0	0	39	12	0	0	3	55
7	3	1	0	26	3	0	0	0	33
8	6	1	0	60	11	0	0	2	80
9	9	2	0	90	3	0	4	0	108
10	3	1	0	116	7	0	0	1	128
12	4	2	0	19	3	0	0	5	33
13	0	0	0	1	0	0	0	0	1
14	1	0	0	306	3	0	67	12	389
15	3	0	0	27	4	0	0	0	34
16	2	0	0	102	3	0	9	1	117
17	3	2	0	26	5	0	1	1	38
18	1	0	0	11	5	0	0	4	21
19	1	2	0	41	6	0	0	0	50
20	0	1	0	29	1	0	0	0	31
21	3	2	0	33	1	0	0	0	39
22	20	0	0	54	1	0	0	1	76
23	4	2	1	189	12	1	6	2	217
25	0	0	0	2	0	0	0	0	2
26	0	0	0	2	0	0	0	0	2
27	0	0	0	250	1	0	13	9	273
28	0	0	0	20	7	0	0	0	27
29	5	5	0	72	5	0	0	1	88
30	1	1	0	31	2	0	0	0	35
31	0	0	0	31	3	1	15	1	51

(Continued)

TABLE 7B (Continued)

THE ORIGIN AND CLASS OF INCOMING REQUESTS

Requesting Library	RPL's Request Classes								
	1	2	3	4	5	6	7	8	TOTAL
32	0	0	0	20	0	0	2	1	23
33	1	1	0	44	8	0	0	3	57
34	0	0	0	41	0	0	1	0	42
35	2	0	0	63	10	1	1	3	80
36	4	0	0	34	2	0	2	0	42
37	7	4	0	88	10	0	0	1	110
38	4	3	0	16	3	0	0	0	26
39	11	6	0	31	11	0	1	1	61
40	2	0	0	78	16	0	3	2	101
41	2	0	0	15	2	0	0	0	19
42	5	5	1	118	16	0	0	2	147
43	0	0	0	10	0	0	0	1	11
45	9	4	0	121	17	1	4	2	158
46	0	0	0	1	0	0	0	0	1
47	5	4	0	79	14	0	0	0	102
48	0	0	0	23	1	0	0	0	24
49	0	2	0	50	3	0	0	0	55
50	0	0	0	17	3	0	4	0	24
51	0	6	0	30	1	0	0	3	40
52	0	0	0	3	5	0	0	0	8
53	9	5	0	37	10	0	0	0	62
54	3	2	0	43	12	0	0	0	60
55	0	0	0	2	0	0	1	0	3
56	2	0	0	44	0	0	5	0	51
57	0	0	0	6	0	0	0	0	6
58	0	0	0	8	0	0	0	0	8
72	1	3	0	27	3	0	2	0	36
TOTAL	139	68	2	2,696	252	4	141	64	3,366

TABLE 8

RESOURCE LIBRARY UTILIZATION AND PERFORMANCE

RESOURCE LIBRARY	REQUEST CLASS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	TOTAL
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	3
% FILLED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	100	100	0	0	0	0	0	100
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
% FILLED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	100
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
% FILLED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
% FILLED	0	0	0	0	0	100	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	1	0	7
% FILLED	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	100	0	100
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
11	0	0	0	2	0	0	6	6	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	13
% FILLED	0	0	0	0	0	0	16	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
% FILLED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
14	45	0	36	97	42	98	133	15	48	36	4	41	459	23	194	11	12	39	51	26	42	27	16	11	45	7	1558
% FILLED	66	0	16	28	26	14	21	0	33	33	25	29	27	0	44	54	16	7	13	0	26	11	18	0	6	28	26
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	2	25	0	1	0	1	0	0	5	0	3	0	0	6	0	0	0	
16	0	0	0	0	0	1	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5
% FILLED	0	0	0	0	0	100	100	0	100	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	100
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
22	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
% FILLED	0	0	0	0	0	0	0	0	0	0	0	0	100	0	100	0	0	0	0	0	0	0	0	0	0	0	100
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	2	0	1	13	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21
% FILLED	0	0	0	50	0	0	23	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
27	0	0	21	42	20	32	47	3	9	5	0	21	218	1	56	0	0	11	16	1	6	1	3	0	20	1	528
% FILLED	12	0	42	50	35	12	17	0	33	40	0	0	37	0	22	0	0	9	25	100	0	0	0	0	35	100	30
% UNAVAILABLE	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5	0	
32	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	2	10	0	2	0	0	0	0	0	0	38
% FILLED	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
% UNAVAILABLE	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
35	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
% FILLED	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	100
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

BEST COPY AVAILABLE

TABLE 8 (Con't.)

| | | |

TABLE 8 (Con't.)

69	1	0	0	6	2	9	10	2	2	2	0	2	17	0	17	0	1	3	4	3	2	0	2	0	3	0	88
% FILLED	0	0	0	50	0	11	20	0	50	50	0	0	17	0	9	0	0	0	25	0	0	0	0	0	33	0	15
% UNAVAILABLE	0	0	0	0	50	11	0	0	0	0	0	50	5	0	35	0	0	33	0	66	0	0	50	0	33	0	
70	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	3
% FILLED	0	0	0	0	0	100	0	0	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	0	0	100
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
% FILLED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	100
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
72	0	0	0	2	1	0	1	0	5	0	0	0	3	5	2	0	0	0	0	0	0	0	2	2	0	0	29
% FILLED	0	0	0	50	100	50	100	0	80	0	0	0	33	80	50	0	0	0	0	0	0	0	50	0	0	0	58
% UNAVAILABLE	0	0	0	0	0	16	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	
73	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
% FILLED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% UNAVAILABLE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL REQUESTS	80	62	52	214	62	192	243	22	120	77	34	88	1116	66	387	32	35	75	90	43	82	52	22	25	96	17	
TOTAL QUERIES MADE	152	83	138	424	163	458	565	66	246	142	41	189	2215	141	753	46	60	170	220	113	182	116	69	58	200	27	
TOTAL REQUESTS FILLED	74	61	36	197	55	161	195	13	91	71	33	76	951	54	348	31	33	53	73	37	77	50	18	22	74	17	
TOTAL UNAVAILABLE	6	1	2	8	9	5	7	2	3	2	1	4	20	0	15	0	1	6	3	8	6	4	0	2	2	0	
PERCENT FILLED	87	98	69	92	88	83	80	59	91	92	97	86	85	81	89	96	94	78	81	86	93	96	81	88	77	100	

BEST COPY AVAILABLE

request has been located and either outprocessed or placed on reserve for the patron. A document is owned but unavailable if it is non-circulating, missing, being rebound, in use (and the resource library will not reserve).

From Tables 7 and 8, it is apparent that the aggregation of requesting libraries, resource libraries, and request classes is in order. Otherwise, we will be attempting to estimate model parameters (elements of data files) based on extremely small samples.

Consider Table 9, which shows the van delivery schedule for most of the member libraries. Grouped together are the locations always visited on the same days. There are seven unique groupings. Each group can be treated as a single library, because all requests produced by the members of the group are collected on the same day(s) and are processed at RPL without distinction among libraries. Furthermore, all documents for each member of each group are delivered (by the same vans) on the same day(s).

Further aggregation of all bookmobile stops into one requesting library can be justified because each location generates only a small number of requests, and because RPL makes no distinction between the bookmobile stops in its routing of requests. All other libraries in the System, affiliate and professional libraries, can be grouped together because they create very few requests. The same can be said about the demand from every requesting library outside the System. An aggregation scheme for requesting libraries is shown in Table 10. DPL and LL remain as distinct requesting libraries because each generates a large amount of demand.

Considering the resource libraries, the right hand column of Table 8 shows the total queries made (and the percent satisfied) at each resource

TABLE 9

THE VAN DELIVERY SCHEDULE EMPLOYED BY RPI

Monday	Tuesday	Thursday	Friday
Sullivan	Illiopolis	Sullivan	Illiopolis
Effingham	Taylorville	Effingham	Taylorville
Shelbyville		Shelbyville	
Clinton		Clinton	Blue Mound
			Morrisonville
Mt. Zion	Mt. Pulaski	Mt. Pulaski	Pawnee
Bethany	Lincoln	Lincoln	Divernon
Pana			
Assumption	Mason City	Lovington	
Moweaqua	Petersburg	Neoga	
Maroa		Toledo	
Atwood		Greenup	
Hammond		Warrensburg	
Cerro Gordo		Weldon	
		Argenta	

TABLE 10

AGGREGATION OF REQUESTING LIBRARIES

GROUP	MEMBERS
1	Clinton, Effingham, Shelbyville, Sullivan
2	Assumption, Atwood, Bethany, Cerro Gordo, Hammond, Maroa, Mt. Zion, Moweaqua, Pana
3	Illiopolis, Taylorville
4	Lincoln, Mt. Pulaski
5	Mason City, Petersburg
6	Argenta, Greenup, Lovington, Neoga, Toledo, Warrensburg, Weldon
7	Blue Mound, Divernon, Morrisonville, Pawnee
8 (Bookmobile stops)	Cowden, Elwin, Findlay, Harristown, Herrick, Macon, Niantic, Oreana, Stonington, Williamsville, Windsor
9	Decatur Public Library
10	Lincoln Library in Springfield
11 (other System libraries)	Adolph Meyer, A.E. Staley, Archer Daniels, Concordia Seminary, Decatur Mem. Hosp., Lincoln Christian Coll , Lincoln Coll., Lincoln Land Comm. Coll., Millikan U., Richland Comm. Coll., Sangamon St. U., Springfield Coll. in IL, RPL,SIU Med.
12 (outside libraries)	LTLS, IVLS, Kaskaskia, Shawnee, Lewis & Clark, Fed. Archives, IL St. Hist. Lib., SIU, ISU, ISL, UI, CPL, John Crerar, Northwestern, UC, Other

library listed. We find that RPL, DPL, LL, UI, and ISL receive a majority of the requests, while the remaining libraries are contacted infrequently. The reason for this is twofold. Often, RPL will contact a member public library to retrieve a book previously loaned by RPL to that library. (These libraries, which have no other use as resource libraries, can be combined with RPL because their resources are in fact part of RPL's collection.) Also, the other libraries may be contacted if it is specifically known that they own the desired document, have a strength in one subject area, or perhaps as a last resort. Indeed, many of these rarely contacted libraries seem to have specialized collections, for they are contacted in only one class, as exemplified by the locations of Moweaqua (in class 19: genealogy) and the Federal Archives (in class 11: census data). It is possible to aggregate the oft disregarded resource libraries into three groups: those within the System that are contacted by RPL to retrieve one of RPL's books, those other libraries within the System, and those that are not within the System. The aggregation scheme shown in Table 11 is the result. Note that CPL and SIU have been grouped together as a single resource library. RPL did not send enough requests to these institutions to be able to confidently determine resource strengths of each library (See Table 8 for individual library utilization and performance). In order to analyze these libraries separately, more data would have to be collected.

The request classes can be aggregated as well by joining together similar subject categories. Three objectives were kept in mind while aggregating request classes. First, those classes with significant numbers of

TABLE 11

AGGREGATION OF RESOURCE LIBRARIES

GROUP	MEMBERS
1	Rolling Prairie Library System Hdqtrs., bookmobile stops, and member public libraries except Moweaqua
2	Decatur Public Library
3	Lincoln Library in Springfield
4	All other System libraries (professional and academic libraries, and Moweaqua)
5	All other libraries except UI, ISL, CPL, and SIU
6	University of Illinois
7	Illinois State Library
8	CPL and SIU

requests before aggregation should not be combined with others, for they individually represent an important part of RPL's work load. Second, aggregations should occur between classes that are similar in subject nature. And finally, the resource libraries contacted should have similar performance in the classes to be aggregated. (See Table 8.) While it was not always possible to satisfy all three constraints, a reasonable mapping from 26 to 13 classes is shown in Table 12.

Given the aggregated number of request classes and the amount of data collected, it is important to determine how confident we can be of the ILLINET program's calculations of probability of success, average waiting time, and average costs. Uncertainties in the input data (due to small sample sizes) result in uncertainty in the performance predictions that are calculated. In collecting data for use in this report, we know that the data represents the parameters of the RPL System not exactly, but within some confidence limits. We wish to determine how these "input" confidence limits affect our "output" confidence limits. In other words, is the sample size large enough to accurately calculate System performance with twelve requesting libraries, eight resource libraries, and thirteen request classes? A detailed discussion of how one makes this determination is beyond the scope of this report, and is the subject of an earlier report in this series (Project Report No. 5, Ref. 5). One of the results of this earlier report was a computer program that will allow one to calculate the effects of input uncertainties on predicted network fill rate, network average waiting time, and network average cost per fill. Information required by this computer program includes

TABLE 12

AGGREGATION OF REQUEST CLASSES

NEW GROUP	OLD GROUP	SUBJECT
1	1	Travel
2	2,11,14	Subjects where specialized libraries are queried (Geneology, Newspapers, Census)
3	3,7,8	Music, Society, Culture, Religion
4	4	Biographies, Autobiographies
5	5,6,26*	Education, Self-improvement
6	9,10	History, Political Science
7	12	Athletics, Sports
8	13	Fiction
9	15,16	Crafts, Hobbies, Recreation, Repair and Maintenance Manuals
10	18	Handbooks, Encyclopedia, Factual Books
11	17,21,23	Science and Engineering
12	19,25	Other
13	20,22,24	Business, Economics, Sociology, Anthropology, (soft sciences)

*The criteria for grouping the original request classes into the new request classes are based on 1) similarity of subject areas, and 2) the fill rates of the unaggregated resource libraries. The noted classes match in subject areas, but the resource libraries have differing fill rates.

the number of requesting libraries, resource libraries, and request classes as well as the average daily demand, the average processing and delivery times, and average costs. The uncertainties are the variances (the square of the standard deviation) of probabilities of success, processing times, and delivery times for resource libraries.

The dimensions, parameters, and associated variances (the last two calculated from the raw data files) of the aggregated RPL System are shown in Table 13. The computer program was used to calculate the effect that the variances in individual resource library fill rates, processing times, and delivery times have on overall System performance. These effects are shown in Table 13. The program indicated that, even with a predicted variance* of 143.54 days squared for average processing time, and 10.17 days squared for average delivery time, we can be 95% confident that the actual values are within 5 percent of our estimates of overall System fill rate, average network processing time, and average cost per satisfied request. This is not to say that the ILLINET program will predict network performance to within 5 percent of the "true" values, but that the error in the final answers due to input uncertainties will not be more than 5 percent. From these results, we can infer that the present aggregation level is sufficient.

Tables 14 and 15 show the total demand in each class from each of the aggregated locations (which will still be referred to as requesting libraries), and the utilization and performance of the aggregated resource libraries. Note that all requesting and resource libraries are contacted. In addition, most resource libraries have had enough contacts in each class so that manipulations to determine processing times and fill rates can be made with reasonable confidence.

*Note: The variance is the square of the standard deviation.

TABLE 13

CALCULATION OF 95% CONFIDENCE LIMITS*

System Dimensions:	System Parameters:	System Uncertainties:
Requesting Libraries (12 Libraries)	Average Resource Library Successful Processing Time.....6.81 days	Variance of Processing Time.....143.54 days^2
Resource Libraries (8 Libraries)	Average Resource Library Failure Processing Time.....2.49 days	Variance of Document Delivery Time.....10.17 days^2
Request Classes (13 Subjects)	Average Document Delivery Time.....4.11 days	
	Overall Fill Rate.....86.1%	

Sample Size (Weeks)

	1	2	3	4	5	6	7	8	9	10	11	12
P	0.17	0.12	0.09	0.08	0.07	0.07	0.06	0.06	0.05	0.05	0.05	0.05
W	0.24	0.14	0.11	0.09	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.05
C	0.28	0.16	0.12	0.10	0.09	0.08	0.07	0.06	0.06	0.06	0.05	0.05

P - Average Network Probability of Success

W - Average Network Waiting Time

C - Average Network Cost per Fill

*For a given value in this table (say α), we can say that we are 95% confident that the true average performance is within 100α percent of the estimated average performance.

TABLE 14

THE ORIGIN AND CLASS OF INCOMING REQUESTS

Requesting Library	Request Class													
	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
1	8	39	49	16	51	21	5	105	60	14	21	21	17	427
2	4	4	36	28	36	26	10	200	71	13	21	16	14	479
3	7	0	9	10	13	1	9	47	22	1	2	9	1	131
4	3	3	31	23	25	23	7	78	21	4	9	15	17	259
5	22	0	11	8	19	5	5	60	27	2	30	8	1	198
6	12	5	33	24	21	14	9	111	38	5	8	31	3	314
7	1	0	20	24	14	10	6	63	26	4	10	10	2	190
8	8	1	48	37	27	29	24	264	88	12	6	16	1	561
9	2	103	27	22	20	19	4	107	18	6	16	22	23	389
10	13	4	42	17	30	18	4	44	32	7	8	27	27	273
11	0	3	8	4	15	8	5	13	9	4	5	8	13	95
12	0	0	3	1	0	3	0	26	7	3	3	3	1	50
TOTAL	80	162	317	214	271	177	88	1118	419	75	139	186	120	3,366

TABLE 15A

RESOURCE LIBRARY UTILIZATION AND PERFORMANCE

REQUEST CLASS

RESOURCE LIBRARY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
1. # of Contacts	74	42	297	207	261	157	90	1093	402	67	119	164	99	3072
% Filled	42	29	42	55	48	50	57	61	56	49	46	44	36	53%
% Owned	42	29	42	56	49	51	57	62	57	49	48	44	37	
% Available	100	100	98	98	97	98	100	99	98	100	96	100	97	
2. # of Contacts	45	27	184	97	147	84	41	459	205	39	70	96	64	1558
% Filled	67	04	19	29	18	33	29	27	45	08	23	10	05	26%
% Owned	67	07	19	29	20	35	29	29	47	13	24	10	06	
% Available	100	50	100	100	93	97	100	95	97	60	94	100	75	
3. # of Contacts	8	1	71	42	53	14	21	210	50	11	9	36	2	528
% Filled	13	00	24	50	23	36	10	37	22	09	00	31	50	30%
% Owned	13	00	25	55	23	36	10	39	22	09	00	33	50	
% Available	100	00	94	91	100	100	100	96	100	100	00	92	100	
4. # of Contacts	01	18	32	06	10	02	00	01	01	05	10	01	01	88
% Filled	00	44	22	33	30	50	00	00	100	60	100	100	100	42%
% Owned	00	50	28	33	30	50	00	00	100	60	100	100	100	
% Available	00	89	78	100	100	100	00	00	100	100	100	100	100	
5. # of Contacts	02	135	14	06	24	10	05	46	21	01	06	08	06	284
% Filled	00	94	29	67	46	80	40	46	48	00	00	75	50	69%
% Owned	00	96	29	83	50	80	40	46	48	00	17	75	50	
% Available	00	98	100	80	92	100	100	100	100	00	00	100	100	
6. # of Contacts	07	07	53	27	29	33	05	23	21	13	43	42	60	363
% Filled	71	00	55	63	52	67	40	48	43	46	60	69	73	59%
% Owned	71	14	60	70	59	70	60	57	48	54	70	74	85	
% Available	100	00	91	89	88	96	67	85	90	86	87	94	86	

(Continued)

TABLE 15A

RESOURCE LIBRARY UTILIZATION AND PERFORMANCE (Continued)

	REQUEST CLASS													
RESOURCE LIBRARY	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
7. # of Contacts	12	12	84	26	100	35	21	160	76	27	36	59	41	689
% Filled	17	00	26	19	33	43	38	28	34	19	39	25	44	30%
% Owned	17	00	27	23	36	43	48	29	36	19	53	27	49	
% Available	100	00	96	83	92	100	80	94	96	100	74	94	90	
8. # of Contacts	02	03	31	12	24	13	05	23	23	07	18	14	14	189
% Filled	50	00	19	58	29	38	20	17	17	29	39	21	21	26%
% Owned	50	33	26	58	38	46	40	22	43	71	50	29	43	
% Available	100	00	75	100	78	83	50	80	40	40	78	75	50	
Total Requests	80	162	317	214	271	177	88	1118	419	75	139	186	120	3366
Total queries	152	245	769	424	648	348	189	2015	799	170	311	420	287	6777
Total filled	70	148	244	197	233	162	78	951	379	53	128	147	109	2899
Percent filled	88	91	77	92	86	92	89	85	90	71	92	79	91	86.1%

40

TABLE 15B

AVERAGE PROCESSING TIMES FOR EACH RESOURCE LIBRARY

RESOURCE LIBRARY	SUCCESSFUL TIME	FAILURE TIME
1	6.43	1.03
2	1.96	1.00
3	15.74	8.42
4	8.38	11.75
5	8.87	19.39
6	7.86	5.13
7	6.32	1.10
8	8.74	6.39

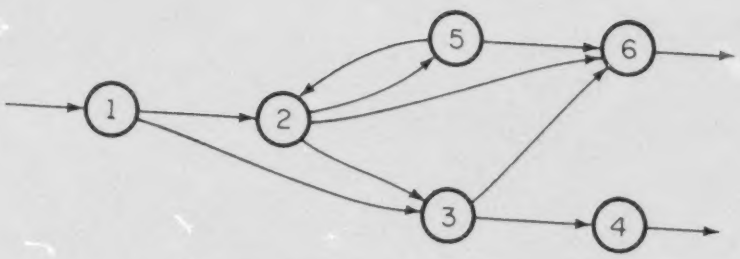
3.5 Formation of Data Files

From Tables 14 and 15, we can begin to form the data files for the ILLINET computer program. Information for the DEMAND file can come almost directly from Table 14. All that needs to be done is to arrange the data so that the ILLINET program can read it.

In order to fill the SRVTIM and SUBFIL files, the individual processing nodes of the resource libraries must be defined. The model of a resource library used by the ILLINET program is shown in Figure 2 (Ref. 2.). Node 1 represents the inprocessing of requests. Node 2 represents the search of the catalog to determine if the material requested is owned. Node 3 represents the obtaining of the material. Node 4 represents the preparation and outprocessing of the document. Node 5 represents the verification of the request. And finally, Node 6 represents the outprocessing of unfilled requests.

In the present version of the ILLINET program, the delivery time of the request to a resource library is not explicitly considered. (The program was originally developed to be applied at the Center level, where requests are TWX'd with a delivery time of zero days.) Therefore, it will be assumed that Node 1 of each resource library includes delivery of the request to the resource library from RPL as well as actual inprocessing at that institution.

Another consideration is the treatment of a request that was not filled by a resource library. The ILLINET program assumes that a request is TWX'd from one resource library to the next with zero delivery time (i.e. the unfilled request goes directly from Node 6 of one resource library to Node 1 of the next). In actuality, most requests unfilled at a resource library will go back to RPL for a decision on subsequent treatment. This



1 In-Process Request
2 Search
3 Obtain Desired Item
4 Out-Process Desired Item
5 Verification
6 Out-Process Request

FP-5405

Figure 2. Model of a Resource Library

difference can be overcome easily by assuming that Node 6 includes both unfilled request outprocessing and delivery back to RPL.

The ILLINET program also assumes that the document(s) satisfying a request are sent (from Node 4) of the successful resource library directly to the requesting library. In actuality, with the exception of ISL, the document(s) are sent first to RPL, and then to the requesting library. (As ISL turns out to be exceptional in other ways as well as this, and will have several paragraphs devoted to it, let us ignore it for now.) This difference can be easily overcome by including in Node 4 the delivery of the document(s) to RPL. We shall discuss the delivery of documents from RPL to the requesting library in later paragraphs.

In summary, the nodes in Figure 2 represent delivery to and processing at a resource library, and delivery of the unsatisfied request or the desired document back to RPL.

The SRVTIM file requires processing times and service rates for each processing node. However, the only processing time information available from the data for each resource library includes the overall processing time for a successful query, and for an unsuccessful query (Table 15). This problem can be overcome by setting to zero all processing times for all except nodes 4 and 6. Thus, the document out-processing and request out-processing nodes are assigned the average times for success and failure, respectively. Obviously, this is not an accurate representation of a real world resource library, because the distribution of processing times among the nodes is incorrect. However, this assumption results in no error from the network (i.e., System) performance point of view.

Note that no information is available to determine service rates. Hence, queueing effects will be ignored and the second part of the SRVTIM file will be empty for this analysis.

Associated with each node are 13 probabilities (one for each subject class) determining the extent to which each path out of a node is utilized. For example, associated with Node 2 are the probabilities that books are owned by the resource library in question in each of the 13 subject categories (o_{ij}). If the probability of resource library i owning a desired document in class 8 is 0.75 ($o_{18} = 0.75$), then three quarters of all fiction requests that enter Node 2 at resource library i will go from Node 2 to Node 3. The other 25 percent will go from Node 2 to Nodes 5 or 6. The probabilities associated with each resource library are as follows:

Probability	Definition
c_{ij}	probability of a request being received with appropriate call number
o_{ij}	probability of the desired document being owned given that the request is verified
a_{ij}	probability of the desired document being available given that it is owned
v_{ij}	probability that a request has been verified previous to its being received
f_{ij}	probability that an unverified request will be forwarded without an attempt to verify it
s_{ij}	probability of the successful verification of a request that was unverified when received

For the relationship of these probabilities to the 6 nodes of a resource library, refer to Project Report No. 2 (Ref. 2). The SUBFIL file requires values for each of these probabilities for each resource library in each request class.

Information available from the raw data provides values for o_{ij} and a_{ij}. (See Table 15.) Assumptions will have to be made for the other probability values. c_{ij}, with the exception of ISL can be considered to be 0.00, because RPL does not have or use catalogs for resource libraries other than ISL. (ISL will be discussed in the next paragraph.) Because no information exists concerning verification at resource libraries, it will be assumed that all requests that enter a resource library are verified, and that no verification is performed. That is, v_{ij}, f_{ij}, and s_{ij} are 1.00 for all resource libraries in all classes.* This last assumption is inappropriate only for Resource Library 1 (RPL). RPL usually verifies requests before they send them out of the System (i.e. to Resource Libraries 5 through 8), and the other Resource Libraries (2, 3, and 4) do not perform the verification service. Only RPL tries to verify requests, and the processing time for this task is somewhat difficult to determine since verification does not necessarily occur during RPL's turn as a resource library. (This is possible because RPL handles the request between each query, and not just when RPL is being utilized as a resource library.) The effect of an inadequate knowledge of verification time will be discussed in detail in Chapter 4.

---

*If v_{ij} = 1.0, the values of f_{ij} and s_{ij} are not really necessary since the resource library never has to process unverified requests. Thus, the values chosen here are arbitrary.

Resource Library 7, ISL, is unique in that RPL uses a filmed card catalog of ISL's collection and that ISL delivers directly to the requesting library. It will be assumed that Resource Library 7 is contacted whenever ISL's card catalog is referenced at RPL.* (This corresponds to ISL's Nodes 1 and 2: inprocessing and catalog search.) This explains the low fill rate and short processing time for unsatisfied requests calculated for ISL in Table 15. In other words, we will assume that ISL is contacted whenever the staff of RPL use this filmed card catalog, even in the cases where requests never actually leave RPL.

When the search is successful, a photocopy of the film is sent to ISL so that the document might be obtained for the successfully searched request (Node 3). Therefore, c_{ij} for Resource Library 7 can also be assigned the value 0.00. (At the end of the data collection period, RPL received two additional filmed card catalogs from UI and SIU. When installed and used, inquiry at these two locations will be quicker because the resource libraries will probably receive fewer unsearched requests.)

Unfortunately, RPL cannot estimate the time required by ISL to satisfy a request, because ISL sends the desired document directly to the requesting library. RPL has estimated that ISL receives the photocopy, processes the request, and delivers (by mail) the desired document to the requesting library in 5 days, and records this estimate on the request slip. Unless information is available showing that ISL has reserved the book, this estimate is utilized as ISL's successful processing time.

As a result of the above assumptions, ISL has a fill rate that is lower than might be expected, has an unsuccessful processing time of about

*Note: In other words, if RPL uses ISL's filmed catalog in an attempt to locate an item and fails, then it is looked at as a failure by ISL.

1 day (it takes about one day of RPL's time to search a batch of requests on their filmed card catalog of ISL's holdings), and has a successful processing time somewhat greater than 5 days (greater because reserved documents take more time to make their way to the requesting library). (See Table 15.)

The DELTIM file, which contains the document delivery times from RPL to the requesting library, requires information for which no data was taken. Assumptions have to be made. Note, from Tables 2 and 3, that, with the exception of the bookmobile stops and requests processed at Resource Library 7, ISL, requests arrive at RPL the same way that documents leave. ISL mails outprocessed documents directly to the requesting library (eliminating the usual practice of sending documents first to RPL). Documents satisfying requests from Requesting Library 8, the bookmobile stops, are mailed to the patron from RPL. With these exceptions, document delivery times should be close to the times to deliver requests from the requesting libraries to RPL. In other words, because requests are generated and sent to RPL from requesting libraries, and desired documents are "generated" and sent to the requesting libraries from RPL, we can say that, with the exceptions noted above, document delivery times to requesting libraries can be assumed to have the same values as request delivery times to RPL. Data was taken so that times of delivery of requests from the requesting libraries to RPL can be calculated. (These values were used in determining the confidence limits in Table 13.)

Now for the exceptions. For the bookmobile routes, an estimate of the average postal delivery times from RPL to the patrons' front doors

will have to be made. A visit to a post office in Champaign, Illinois yielded a consensus of opinion among the postal clerks that a book mailed to a location within a 50 mile radius of the origin would take between three and four days to reach its destination. Since this figure is close to the delivery time of a request from the bookmobile stop to RPL (3.11 days), there is no reason to change the latter. As for delivery from ISL, since the time to deliver a document to the requesting library is included in its overall processing time, and the document does not go first to RPL, the delivery times to all requesting libraries from ISL will be set to zero. The values of delivery times to be placed in the DELTIM file are shown in Table 16.

RPL incurs no per request costs for its operations; operating under a yearly budget, RPL does no per request accounting. However, the R and R Centers are under a per request budgeting scheme. Table 17 shows the amounts that each of the R and R centers are reimbursed for each searched and each filled request that they process. As RPL desires to economize, these costs should be considered during analysis. Therefore, these costs will be entered into the COST file for Resource Libraries 6, 7, and 8. As SIU and CPL each processed about the same number of requests for RPL, the costs entered for Resource Library 8 will be the average of the costs for SIU and CPL. A list of processing costs for all of the resource libraries is in Table 18. Note that Resource Library 7, ISL, has a search cost of 0.00 dollars. The reason for this is that RPL, in most cases searches the request with the filmed card catalog (under no reimbursement plan) and sends a photocopy of the film to ISL. In other words, ISL receives, with rare exception, only searched requests from RPL. Hence, the cost of searching for ISL is 0.00.

TABLE 16

THE AVERAGE DOCUMENT DELIVERY TIME TO ALL REQUESTING LIBRARIES FOR REQUESTS FILLED AT ALL BUT RESOURCE LIBRARY 7*

Requesting Library	Average Delivery Time (in days)
01	4.20
02	4.59
03	4.37
04	4.43
05	4.35
06	4.35
07	6.48
08	3.11
09	3.08
10	2.99
11	1.83
12	4.83

*Resource Library 7, ISL, has, as explained in the text, a document delivery time to all requesting libraries of 0.00 days entered into the DELTIM file.

TABLE 17

PROCESSING COSTS PER REQUEST FOR THE R AND R CENTERS

Center	Search Cost	Fill Cost
UI	1.35	1.35
ISL	1.10	1.10
CPL	1.10	1.10
SIU	1.10	1.10

TABLE 18

PROCESSING COSTS PER REQUEST FOR ALL RESOURCE LIBRARIES

Resource Library	Search Cost	Fill Cost
01	0.00	0.00
02	0.00	0.00
03	0.00	0.00
04	0.00	0.00
05	0.00	0.00
06	1.35	1.35
07	0.00	1.10
08	1.10	1.10

All five data files, DEMAND, SRVTIM, SUBFIL, DELTIM, and COST, are now defined.

3.6 Other Manipulations of Interest

Included in this section are other tables and figures showing performance of the RPL System. Table 19 shows the average processing time to satisfy a request and the average processing time to return an unfilled request to RPL for each of the unaggregated resource libraries contacted. This information is not essential to subsequent analysis, but may be of interest to RPL.

Figures 3, 4, and 5 show frequency histograms of turn around time (from in-processing date to out-processing date) of all requests, of all satisfied requests, and all unsatisfied requests. Note that only 3252 requests entered into the raw data files had enough information to determine this time. The times stated here do not include the time to deliver the desired document or the cancelled request back to the requesting library. Note that the average turn around time for all requests is 14.65 days, and that 90 percent of all requests are processed within 36 days.

TABLE 19

THE AVERAGE PROCESSING TIMES IN DAYS FOR EACH RESOURCE LIBRARY*

Resource Library	Satisfaction	Failure
2	3.33	0.00
3	3.00	0.00
5	0.00	0.00
6	8.00	0.00
8	6.57	0.00
11	10.33	8.20
13	0.00	1.00
14	1.96	1.00
16	11.00	0.00
22	4.00	0.00
24	9.50	18.36
27	16.82	8.42
32	1.00	15.57
35	5.00	0.00
36	13.43	1.80
42	5.00	0.00
52	6.00	0.00
55	9.67	4.00
56	6.72	1.03
57	7.63	18.35
58	18.21	29.11
59	0.00	0.00
60	12.66	2.00
61	4.00	0.00
62	9.95	0.00
63	3.36	5.50
64	8.15	7.97
66	6.31	1.10
67	7.86	5.13
68	10.31	4.94
70	1.00	0.00
71	19.00	0.00
72	15.08	9.00
73	0.00	0.00

* Those resource libraries not listed were not contacted during the data collection period.

TOTAL: 3252 REQUESTS NOT USED: 252 AVERAGE TURNAROUND TIME: 14.65 DAYS
NOTE: DAY 55 INCLUDES REQUESTS COMPLETED ON OR AFTER DAY 55

Figure 3. Turn Around Time for All Requests

BEST COPY AVAILABLE

TOTAL:2788 AVERAGE TURNAROUND TIME FOR SATISFIED REQUESTS:13.29 DAYS
NOTE: DAY 55 INCLUDES REQUESTS COMPLETED ON OR AFTER DAY 55

Figure 4. Turn Around Time for Satisfied Requests

BEST COPY AVAILABLE

TOTAL 464 AVERAGE TURNAROUND TIME FOR CANCELLED REQUESTS:22.82 DAYS
NOTE: DAY 55 INCLUDES REQUESTS COMPLETED ON OR AFTER DAY 55

Figure 5. Turn Around Time for Cancelled Requests

CHAPTER 4

POLICY FORMULATION AND ANALYSIS

4.1 Introduction

In this chapter the request routing policies, the order in which the resource libraries are contacted in an attempt to satisfy a request are formulated. The objective of this chapter is to analyze various routing policies with the ILLINET program and compare System performance with present performance. Finding an optimal policy, one that achieves the best possible System performance, is certainly a desirable goal, but unfortunately no definition exists yet for the term "best". In other words, no optimal tradeoff between maximizing network fill rate and minimizing processing times and costs has yet been defined. Therefore, a broad range of policies will be analyzed and their impact on network performance will be discussed with a goal of providing a "reasonable" set of policy recommendations.

4.2 Analysis of RPL's Present Policy

RPL's present policy will now be formulated and analyzed. For each request class, the initial resource library to which the request is sent must be specified. Then, for each class, the subsequent resource libraries where unfilled requests are referred must be defined. RPL's present routing policy is shown in Table 20. Note that less than eight resource libraries are listed in each class and that, in some classes, only two or three are listed. The resource libraries not listed in each class were contacted less than 20 times in those classes during the entire data collection period. For this reason, reliable determinations of resource

TABLE 20

RPL's PRESENT POLICY

Request Class	Referral Number 0	1	2	3	4	5	6
1	1	2					
2	5	1	2				
3	1	2	7	3	6	4	8
4	1	2	3	7	6		
5	1	2	7	3	6	5	8
6	1	2	6	7			
7	1	2	7	3			
8	1	2	3	7	5	6	8
9	1	2	7	3	8	6	5
10	1	2	7				
11	1	2	6	7			
12	1	2	7	6	3		
13	1	2	6	7			

PERFORMANCE PREDICTIONS

	Referral Number 1	2	3	4	5	6
Average Yearly Demand	14025	14025	14025	14025	14025	14025
Average No. of Satisfied Requests	9371	11175	11987	12721	13042	13162
Fill Rates	0.668	0.797	0.855	0.907	0.930	0.939
Average Delay (Days)	9.920	10.650	11.170	11.910	12.480	12.750
Average Yearly Costs	0	2492	3554	5333	6321	6792
Average Unit Costs	0.000	0.220	0.300	0.420	0.480	0.520

NOTE: See Table 11 (p. 33) for definitions of resource libraries and Table 12 (p. 35) for definitions of request classes.

strengths could not be made (even with the aggregations that took place). Hence, in policy formulation, those libraries whose calculations of strengths are unreliable are simply not contacted. Two reasons motivated this decision. First, these libraries were contacted few times in those classes (either because they were known to be weak, or were simply overlooked) and their exclusion affects only a small percentage of the requests. Second, inclusion of, for example, Resource Library 4 in classes 9, 11, 12, and 13 would require that we accept Resource Library 4's fill rate in these classes as 100 percent. As these estimated fill rates are based on one request in each class (10 in class 11), we are quite reluctant to accept these estimates as sound.

The policy discussed above was used with the ILLINET program and the results are shown in Table 20. The ILLINET program was run 6 times. On the first run, the number of referrals allowed was 1. Each time thereafter, the number of allowed referrals was increased by one until the maximum was reached.

For comparison purposes, consider RPL's overall fill rate (from Table 15) and average waiting time from inprocessing to document delivery (which is the turn around time from Figure 2 plus the average document delivery time from Table 13). The predicted fill rate is 9.1 percent higher than the measured fill rate (93.9 predicted vs. 86.1 actual). To explain this difference, consider that the "average" policy of Table 20 indicates that many requests are processed at as many as 7 resource libraries. Yet, surely not all unsatisfied requests go to so many libraries and, those that are processed at fewer libraries cause the actual fill rate to be decreased.

With respect to processing times where the calculated time is 32.2% less than the actual (12.75 days calculated vs. 18.81 days actual), several time consuming events take place in actuality that are not included in the representation input to the model. The first is the verification of requests. RPL will, many times, consume a day or two verifying a batch of requests. The next event is weekends. If an unfilled request returns on a Friday, it may not be sent to the next resource library (or be cancelled) until the following Monday. (Recall from Chapter 2 that employees at RPL handle the request between each query.) Also, the employees at RPL may have such a work load that a returned request may not be reprocessed for several days. Not one of these events is accounted for in the representation developed for the ILLINET program in Chapter 3. The fact that approximately six days are lost due to extra time spent at RPL is significant. This point will be discussed further in the recommendations (Section 4.5).

The important point to be gleaned from these comparisons is that our representation of RPL's present policy is, at best, a description of the average policy and thus, is not an adequate description of what happens to each individual request. However, the differences noted need not concern us too much if we concentrate on analyzing relative improvements of policy alternatives.

4.3 Intuitively Reasonable Policies

Keeping these discrepancies in mind, other operating policies can now be proposed, analyzed, and compared with the present policy. The first policy of interest is suggested by the statistics in Table 15.

Resource Library 1, RPL has a processing time for filling requests of over six days. When referring back to Chapter 2, it would seem that most requests that are to be filled could be filled in one day. The reason the time is so large is that, for a small percentage of requests processed at RPL (approximately 10 percent), the processing time is several weeks. This is due to the fact that RPL reserves the document at one of its member libraries and waits for its return, or holds the request for four weeks (as described in Chapter 2) if the document is missing. If RPL would hold a request for only a week, fill rate at RPL might suffer, but processing time at RPL and overall processing times might be improved. Table 21 shows how RPL's performance would be altered if a policy were adopted that constrained processing time at RPL to no longer than seven days. Note that RPL's fill rate would drop from 53 to 41 percent, but that processing time for satisfied requests drops from 6.4 to 1.2 days. Failure time rises from 1 to 2.2 days. Running the ILLINET model with the same routing policy, but with this new performance of Resource Library 1, the results in Table 22 are obtained. Note that fill rate suffers (by several percent) and that costs rise, for more requests are processed at the R and R centers. However, at least a day is saved in turn-around time. While this may not at first appear attractive, if RPL kept the reservation on the documents, but went ahead and checked the other resource libraries in the route, the still unsatisfied requests could be filled when the reserved documents finally arrive at RPL. In this way, overall fill rate would be unaffected while average processing times would decrease.

TABLE 21

RESULT OF HOLDING A REQUEST AT RPL FOR A MAXIMUM OF 7 DAYS

RPL'S FILL RATE (%)

	Request Class													
	1	2	3	4	5	6	7	8	9	10	11	12	13	Overall
Present Procedure	42	29	42	55	48	50	57	61	56	49	46	44	36	53%
One Week Maximum	28	26	34	44	44	42	51	40	51	49	34	35	32	41%

RPL'S PROCESSING TIME (DAYS)

	Successful Time	Failure Time
Present Procedure	6.43	1.03
One Week Maximum	1.22	2.23

TABLE 22

RPL'S PRESENT POLICY WITH HOLDING REQUEST FOR ONLY ONE WEEK

Request Class	0	1	2	3	4	5	6
1	1	2					
2	5	1	2				
3	1	2	7	3	6	4	8
4	1	2	3	7	6		
5	1	2	7	3	6	5	8
6	1	2	6	7			
7	1	2	7	3			
8	1	2	3	7	5	6	8
9	1	2	7	3	8	6	5
10	1	2	7				
11	1	2	6	7			
12	1	2	7	6	3		
13	1	2	6	7			

PERFORMANCE PREDICTIONS

	Referral Number 1	2	3	4	5	6
Average Yearly Demand	14025	14025	14025	14025	14025	14025
Average No. of Satisfied Requests	8212	10467	11483	12008	12850	12996
Fill Rates	0.586	0.746	0.819	0.856	0.916	0.927
Average Delay (days)	6.330	8.610	9.570	10.740	11.620	11.970
Average Yearly Costs	0	2817	4146	6133	7516	8133
Average Unit Costs	0.000	0.270	0.360	0.490	0.590	0.630

NOTE: See Table 11 (p. 33) for defiritions of resource libraries and Table 12 (p. 35) for definitions of request classes.

The next item of interest is to consider the impact of the new filmed card catalogs on network performance. Fill rates, waiting times and costs will be affected. If RPL uses these catalogs, the usefulness of the R and R Centers would increase greatly. Knowledge of the collections at the R and R Centers would be available quickly and at no processing cost. All Centers could probably be searched in a single day. The impact of these new catalogs cannot be examined exactly. No data is available to determine the effect on fill rates at Resource Libraries 6, 7, and 8, nor the processing times to fill a request there. However, if the item requested is not owned at Resource Libraries 6 through 8, the cost will be zero, and only a single day will be lost due to searching the card catalogs. Let us assume that filmed card catalogs are available for all four centers. We shall set the failure processing times for Resource Libraries 6 (UI) and 7 (ISL) to 0.25 days each, and the failure processing time for 8 (CPL and SIU) to 0.50. Hence, all f[illegible] catalogs could be searched in one day. In addition, let us set the search costs at the three libraries to 0.00. As we have no information about impact on fill rates (o_{ij} and a_{ij}) and successful processing times, we shall not alter these parameters. Finally, let us specify a routing policy where, when possible, the route shall be some combination of Resource Libraries 1, 2, 6, 7, and 8. The policy and the results of implementing it with the model are shown in Table 23. Comparing the results with those for RPL's present policy, we see a trend towards satisfaction of more requests in the early referrals. Perhaps more importantly, more referrals can take place at less cost in approximately the same number of days.

TABLE 23

POLICY USING FILMED CATALOGS

Request Class	0	1	2	3	4	5	6
1	1	2					
2	5	1	2				
3	1	2	6	7	8	3	4
4	1	2	6	7	3		
5	1	2	6	7	8	3	5
6	1	2	6	7			
7	1	2	7	3			
8	1	2	6	7	8	3	5
9	1	2	6	7	8	3	5
10	1	2	7				
11	1	2	6	7			
12	1	2	6	7	3		
13	1	2	6	7			

PERFORMANCE PREDICTIONS

	Referral Number					
	1	2	3	4	5	6
Average Yearly Demand	14025	14025	14025	14025	14025	14025
Average No. of Satisfied Requests	9371	11833	12417	12687	12933	13162
Fill Rates	0.668	0.844	0.855	0.905	0.922	0.939
Average Delay (Days)	9.920	10.730	10.640	10.770	11.000	11.230
Average Yearly Costs	0	3304	3937	4158	4158	4158
Average Unit Costs	0.000	0.280	0.320	0.330	0.320	0.320

NOTE: See Table 11 (p. 33) for definitions of resource libraries and Table 12 (p. 35) for definitions of request classes.

4.4 Value Oriented Policies

The resource library that has the most value in a given request class should be queried first. The routing policy that, in each class, sends requests to resource libraries in descending order of their values will produce the optimal system performance. Unfortunately, as noted before, "value" is difficult to define. Let us set down in the next paragraphs extreme definitions of "value" and examine their effects on System performance.

Let us first define value as strength. The probability that a resource library can fill a request is the probability that the desired document is owned times the probability that an owned document is available (o_{ij} a_{ij}). The higher this product, the higher the probability that a given request will be satisfied. As an example, Resource Library 2 has an o_{28} of 0.29 and an a_{28} of 0.95 (Table 15). This means that a librarian has a 29 percent chance of finding a fiction request in DPL's card catalog, and, if he/she does find the desired document listed, a .95 chance of finding the book on the shelf or being able to reserve the document. Hence, the probability of satisfying a fiction request at DPL is (0.29)(0.95) = .27 or 27%. In other words, we assign a strength value of 0.27 to Resource Library 2 in class 8.

Strength values are assigned to all resource libraries in all classes. Then, in each request class, the resource libraries are ordered from high value to low. This ordering, shown in Table 24, is our routing policy. The ILLINET program analysis of the strength policy is shown in the same table.

TABLE 24

STRENGTH POLICY

Request Class	0	1	2	3	4	5	6
1	2	1					
2	5	1	2				
3	6	1	7	3	4	2	8
4	6	1	3	2	7		
5	6	1	5	7	8	3	2
6	6	1	7	2			
7	1	7	2	3			
8	1	6	5	3	7	2	4
9	1	5	2	6	7	3	8
10	1	7	2				
11	6	1	7	2			
12	6	1	3	7	2		
13	6	7	1	2			

PERFORMANCE PREDICTIONS

	Referral Number					
	1	2	3	4	5	6
Average Yearly Demand	14025	14025	14025	14025	14025	14025
Average No. of Satisfied Requests	11137	12254	12742	12958	13087	13162
Fill Rates	0.794	0.874	0.908	0.924	0.933	0.938
Average Delay (Days)	11.670	12.360	13.160	13.510	13.770	13.950
Average Yearly Costs	16662	16871	17375	17675	17675	18137
Average Unit Costs	1.500	1.380	1.360	1.360	1.350	1.380

NOTE: See Table 11 (p. 33) for definitions of resource libraries and Table 12 (p. 35) for definitions of request classes.

Let us compare this with the analysis of RPL's present policy (Table 20). Note that fill rates are higher in the earlier referrals with the strength policy. On the other hand, operating with the strength policy takes several days longer to process an average request. Indeed, under the present policy, three referrals can be made in the same time it takes to make one referral with the strength policy. Also, the cost per fill with the strength policy is on the order of 5 times that with the present policy. This is because the strength policy specifies visiting more R and R centers (which have longer processing times) in the early referrals.

Thus, resource library strength is not necessarily a good definition of value. Average network waiting time increased (as did costs) because the R and R centers, with long processing times were contacted early in the referral route. Therefore, let us select as our next value policy a time policy.

By concerning ourselves with time, we consider resource libraries with the shorter expected processing times in each class as having higher values. The question is how to determine expected processing times. An example will help clarify this point. Suppose the Resource Library i has a fill rate in class j of 25 percent (i.e. $o_{ij}\ a_{ij} = 0.25$). In addition, the Library can satisfy a request in 9 days, but will return an unfilled request in 3 days. Hence, when RPL sends a request to Resource Library i, the expected processing time is $(0.25)(9) + (0.75)(3) = 4.5$ days. In other words, if RPL sends 100

requests to resource library i, RPL can expect 25 to be filled (at 9 days average processing time for each request) and 75 to be returned unfilled (in 3 days). Thus, the "average" or expected processing time for Resource Library i is 4.5 days.

Expected time values are calculated for all resource libraries in all classes. Recall that the average processing times for each resource library do not change between request classes, but fill rates do vary. For example, the successful processing time for Resource Library 6 is 7.86 days. This average value is assumed to be invariant. However, fill rates for each class are different. Hence the expected processing time in each class will be different. The resource libraries are then ordered in each class from low expected time to high expected time. This ordering is the routing policy and is shown in Table 25.

The results produced by the ILLINET program are shown in the same table. Let us compare this with RPL's present policy. Note that after the first referral, fill rate does not suffer too much, and that a day or two is saved at each referral. However, costs are on the order of being twice as high with the time policy.

With the time policy we cannot say that we have improved network performance, for our overall fill rate is not as high as with the present policy despite the lower average processing time. On the other hand, the strength policy is not an optimal policy; even though fill rate is improved, average processing time and costs are high. Perhaps some compromise between strength and time will both increase

TABLE 25

TIME POLICY

Request Class	0	1	2	3	4	5	6
1	2	1					
2	2	1	5				
3	2	7	1	6	8	3	4
4	2	7	1	6	3		
5	2	7	1	6	8	3	5
6	2	7	1	6			
7	2	7	1	3			
8	2	7	1	6	8	3	5
9	2	7	1	6	8	3	5
10	2	7	1				
11	2	7	1	6			
12	2	7	1	6	3		
13	2	1	7	6			

PERFORMANCE PREDICTIONS

	Referral Number 1	2	3	4	5	6
Average Yearly Demand	14025	14025	14025	14025	14025	14025
Average No. of Satisfied Requests	6733	10754	12417	12687	12933	13162
Fill Rates	0.480	0.767	0.885	0.905	0.922	0.939
Average Delay (Days)	6.910	8.950	9.770	10.040	10.500	10.930
Average Yearly Costs	2933	3083	9354	10687	10687	10687
Average Unit Costs	0.440	0.290	0.750	0.840	0.830	0.810

NOTE: See Table 11 (p. 33) for definitions of resource libraries and Table 12 (p. 35) for definitions of request classes.

overall fill rate in the lower referrals and decrease average processing time without affecting costs significantly.

Let us define value as the probability of success divided by the expected processing time for each resource library in each class. This compromise value was used in earlier reports and is somewhat arbitrary. However, it appears to behave appropriately. As the probability of success increases, so does value. Hence, a stronger resource library may be assigned a higher value. In addition, as average processing time decreases, value increases. As a result, a resource library with a shorter processing time may be favored with a higher compromise value. However, this definition of value is a compromise between time and strength, and as such a resource library that is weaker in a given request class may be assigned a higher value than a strong library because it has a very short expected processing time in that class. The compromise values are calculated for every resource library in every request class. Then in each class, the resource libraries are ordered from high value to low value. The routing policy is shown in Table 26 as are the calculations of the ILLINET program.

Let us compare the compromise policy with RPL's present policy. Note that fill rates are increased in all but the 6th referral block and that average processing times are shorter. Costs, however, are still higher though not as high as the time and strength policies.

Note that costs were not considered in the formulation of any routing policy. These per request processing costs are not incurred by the RPL system, but do obligate the State of Illinois to the R and R

TABLE 26

COMPROMISE POLICY

Request Class	0	1	2	3	4	5	6
1	2	1					
2	1	5	2				
3	2	1	7	6	8	3	4
4	2	1	6	7	3		
5	2	1	7	6	8	5	3
6	2	1	7	6			
7	2	1	7	3			
8	2	1	7	6	5	3	8
9	2	1	7	6	5	8	3
10	1	7	2				
11	2	1	7	6			
12	1	6	7	2	3		
13	7	1	6	2			

PERFORMANCE PREDICTIONS

	Referral Number 1	2	3	4	5	6
Average Yearly Demand	14025	14025	14025	14025	14025	14025
Average No. of Satisfied Requests	9775	11196	12417	12875	13075	13162
Fill Rates	0.697	0.798	0.885	0.918	0.932	0.939
Average Delay (Days)	9.340	9.390	9.970	10.390	10.830	11.050
Average Yearly Costs	1271	3525	8246	8742	8846	9062
Average Unit Costs	0.130	0.310	0.660	0.680	0.680	0.690

NOTE: See Table 11 (p. 33) for definitions of resource libraries and Table 12 (p. 35) for definitions of request classes.

Centers. If one wishes to consider costs when formulating a routing policy, all he need do is include some expected value of processing cost in a compromise formula similar to the one above. However, no accurate determination can be made of processing costs, because the RPL headquarters recently began the use of filmed card catalogs of UI and SIU (but not CPL) in addition to the established ISL catalog. As a result, only searched requests with call numbers will be referred to these centers, greatly reducing the number of searches and charges incurred at UI and SIU.

4.5 Recommendations

No optimal routing policy was found in Sections 4.3 and 4.4, because, first, the best trade-off between network fill rate, average waiting time, and average cost per fill has not been defined and second, recent additions to the RPL headquarters (the filmed card catalogs of UI and SIU) may change the parameters (costs and processing times) of the network. However, from the analysis, several suggestions recommend themselves.

As pointed out in Chapter 2, the RPL headquarters may hold requests 4 weeks or longer waiting for a missing and/or reserved books to become available. RPL could most probably reduce the average network processing time by keeping these requests inactive for only a week. RPL could continue seeking the missing documents and retain reservations on documents in circulation, and at the same time query other resource libraries. In many cases requests will be filled before the missing

document is found or the reserved document returns. Most likely this practice will not affect fill rate, but will shorten the average network waiting time.

A second practice presently used by RPL that lengthens overall network processing time was mentioned in Section 4.2. The actual processing time is approximately 6 days longer than the value calculated by the ILLINET program. The reasons for the difference are time taken to verify a request, the presence of weekends, and other time taken between referrals to decide on the next source to be queried. RPL loses time by handling each request between each referral; perhaps not all 6 days, but a significant portion of it. If RPL would specify the referral route before the first referral is made and allow the referrals to take place automatically, several days would be saved on the average network processing times. Exactly how much time would be saved cannot be determined.

Another change that will improve network performance is the filmed card catalogs. RPL is provided with three excellent opportunities by including the use of these catalogs in early referrals. First, three very large collections can be queried in a very short time. This fact alone means the improvement of fill rate and average network processing time, or a large batch of requests can be referred to the three catalogs (UI's, SIU's, and ISL's) is a single day. Second, State money can be saved. By sending requests to UI, SIU and ISL with call numbers, the search costs charged to the State from these

Centers can be eliminated. Third, RPL has the opportunity to accurately determine the strength of UI, SIU, and ISL in each class. By keeping a tally sheet and processing many requests with the filmed catalog reader, RPL can quickly calculate the strength (and subsequently value) of UI, SIU, and ISL.

Considering all of the above, the following recommendations are made.

1. RPL should hold requests waiting for a missing or reserved document only 7 days, continue to search for these documents, but process the request at other resource libraries so as to decrease average network processing time.
2. RPL should allow requests to be referred automatically, (at least at the Center level) after specifying the route for each request so as to decrease average network processing time.
3. RPL should use the filmed card catalog early in the referral route to help decide which resource libraries are to be queried and in which order.

It is suggested that <u>initially</u>, RPL adopt a routing policy similar to that shown in Table 27. This policy specifies that RPL be checked first, and that unfilled requests be checked at the three filmed card catalogs. The three R and R Centers (UI, ISL, and SIU) are ordered in each class according to the strength criterion in Table 24. If no information about the Centers is available (as in class 10, for example) the Centers are ordered in that class UI,

TABLE 27

RECOMMENDED POLICY

Referral Number

Request Class	0	1	2	3	4	5	6	7
1	RPL	UI	ISL	SIU	DPL			
2	RPL	UI	ISL	SIU	Special Libraries	DPL		
3	RPL	UI	ISL	SIU	DPL	CPL	LL	Other System Libraries
4	RPL	UI	ISL	SIU	DPL	LL		
5	RPL	UI	ISL	SIU	DPL	CPL	Outside the System	LL
6	RPL	UI	ISL	SIU	DPL			
7	RPL	ISL	UI	SIU	DPL	LL		
8	RPL	UI	ISL	SIU	DPL	Outside the system	LL	CPL
9	RPL	UI	ISL	SIU	DPL	Outside the system	CPL	LL
10	RPL	ISL	UI	SIU	DPL			
11	RPL	UI	ISL	SIU	DPL			
12	RPL	UI	ISL	SIU	DPL	LL		
13	RPL	UI	ISL	SIU	DPL			

ISL and SIU. Referrals subsequent to queries made because of information found in the filmed card catalogs are ordered according to the compromise value policy (Table 26).

With this initial policy, RPL can make a large number of contacts in a short period of time, many without leaving Decatur. A qualitative or quantitative determination of current resource library values can be quickly determined. After a period of time, RPL can adjust the routing policy as the relative values of the resource libraries become apparant, or change.

As a final comment, our definitions of "value" have been somewhat arbitrarily but nevertheless intuitively reasonable. It would seem to be worthwhile for RPL and possibly the State to consider developing a quantitative definition of the value of a resource library as outlined by example in Section 4.4.

REFERENCES

1. W. B. Rouse, J. L. Divilbiss, and S. H. Rouse, A Mathematical Model of the Illinois Interlibrary Loan Network: Project Report No. 1, Coordinated Science Laboratory Report No. T-14, University of Illinois at Urbana-Champaign, November 1974, ERIC No. ED 101 667.

2. W. B. Rouse, J. L. Divilbiss, and S. H. Rouse, A Mathematical Model of the Illinois Interlibrary Loan Network: Project Report No. 2, Coordinated Science Laboratory Report No. T-16, University of Illinois at Urbana-Champaign, March 1975, ERIC No. ED 107 287.

3. W. B. Rouse and S. H. Rouse, A Mathematical Model of the Illinois Interlibrary Loan Network: Project Report No. 3, Coordinated Science Laboratory Report No. T-26, University of Illinois at Urbana-Champaign, April 1976, ERIC No. ED 124 179.

4. W. B. Rouse and S. H. Rouse, A Mathematical Model of the Illinois Interlibrary Loan Network: Project Report No. 4, Coordinated Science Laboratory Report No. T-28, University of Illinois at Urbana-Champaign, June 1976, ERIC No. ED 126 879.

5. W. B. Rouse and S. H. Rouse, A Mathematical Model of the Illinois Interlibrary Loan Network: Project Report No. 5, Coordinated Science Laboratory Report T-31, University of Illinois at Urbana-Champaign, October 1976, ERIC No. not yet available.

APPENDIX 1

SUGGESTED ROUTING OF REQUESTS

Paul Johnson, ILL Dept. Supervisor

Because of the limited knowledge we have of the holdings of most of the libraries in ILLINET, the routing of requests is still a fairly subjective routine. The following are rough guidelines only and personal knowledge or even a "hunch" on the part of the person assigning the routing may override these suggestions.

1) A title which is published by a university press or which is of very academic nature can be sent directly to UI. These requests usually bypass LL and ISL. If the material is extremely academic they may even bypass RPL and DPL, going to UI at the very beginning

   If not at UI, they try SIU next. If not at UI or SIU, there are several choices. Go back to one of the places that was bypassed, for example either LL or DPL depending on the subject (see following guidelines). Try ISL especially if it is in the social sciences, history, fiction or the arts. It is less promising to try ISL if it is in the hard sciences, i.e. math, physics, etc...

   Another choice would be to go on to CPL using roughly the same guidelines as for ISL. However always go to ISL or a local source first and avoid CPL if possible. We have found very little at CPL.

Other possibilities for an academic title not at UI or SIU would be to try one of our academic affiliates. Millikin or SSU are the two best possibilities. We could also try for an NUC location. I usually do this only in the case of very old, very academic titles because many of the libraries listed in NUC will not loan in-print titles. I also may cancel at this point.

In general the older and more academic the title the less likely it will be any place other than UI. There are three centers of last resort, John Crerar, Northwestern and University of Chicago. However we cannot send requests directly to these institutions. Instead they must be referred by UI.

2) The vast majority of our requests are for titles of a popular, general nature put out by a trade publisher. In general these would go first to RPL and DPL. Then those in the worst shape (no author, suspicious title, etc...) are pulled out to be verified. The rest can go on to either LL or ISL or both. If not at any of these four and the title has been verified it can be tried at Lincoln Trails or CPL. Again, CPL has so far given very poor results.

3) There are some specialized areas for which we can go to specific collections.

   a) Geneology - Moweaqua, Shawnee Library System - SIU also has some strength in this area.

   b) Illinois County Histories - ISL, UI, Shawnee, Moweaqua

c) Religious and Inspirational Literature - Concordia, Lincoln Christian

d) Medicine and Health Sciences - SIU Medical in Springfield

e) Law Enforcement - Lewis and Clark Library System

f) Auto and Truck Repair Manuals - Kaskaskia Library System

g) State Newspapers on Micro-film - Illinois State Historical Society

h) Federal Censuses on Micro-film - Chicago branch of the federal archives

i) Government, Political Sciences, Public Affairs, etc... - Illinois State Library

j) National Newspapers on Micro-film - UI

In addition there are three books in the reference collection which may suggest additional specialized collections.

a) Lee Ash's Subject Collections; A Guide R026/ASH

b) Beth Hamilton's Libraries and Information Centers in the Chicago Metro Area R027/H

c) Robert Downs' Guide to Illinois Library Resources R011/DOW

Also useful is the Interlibrary Loan Policies Directory by Sarah Thomson R024.602/THO. This is a guide to the lending and copying policies of the listed institutions.

4) The majority of requests received are unverified. With just author and title we will usually check RPL, DPL, LL and ISL. If we are going to send the title anyplace else, we usually try to verify first.

5) We occasionally receive requests for photo-copies of journal articles. There are many serials lists on the reference table and in the reference collection which can be used to find a location. We also have the most recent UI serials list on micro-film.

6) We usually try four places for records or cassettes; RPL, DPL, LL and ISL.

7) The newer the book the harder to find. If book is brand new or in Forthcoming, there is little hope of getting it from an R & R center. We may wish to purchase ourselves or suggest purchase to LL or DPL, depending on subject. Purchase Suggestion Forms are in my top right hand drawer.

8) When there does not seem to be any other locations from which there is a reasonable probability of borrowing the item I usually cancel the request by writing the reason for cancellation in red ink acorss the top copy of the request and returning it to the member library.

9) To summarize, if the request does not fall in the area of one of the special collections listed in (3) then try to decide whether it is of an academic or popular nature. If academic, try UI, SIU, an academic affiliate or depending on subject, perhaps ISL, DPL, or LL. If popular, try RPL, DPL, LL, ISL or Lincoln Trails, perhaps CPL. Try to verify before sending outside system. Newest books may have to be considered for purchase. Cancel after reasonable effort.

APPENDIX 2

DATA COLLECTION PERIOD

In order to collect a desired data sample size, collection of data must continue after the end of the specified time period. For this report all requests inprocessed at RPL between 14 June 1976 and 6 September 1976 were used as the data sample. Many requests inprocessed near the end of this time period did not complete processing until weeks after 6 September. In order to include these requests in the sample, data collection had to continue after 6 September. It would be useful to have a general method for determining how long one should continue to collect data in order to get virtually all of the requests. Let us discuss the formation of a very simple queueing model of the RPL system and see if it can accurately predict the time that we should allow for all requests to complete processing.

To make the mathematical model simple, assumptions will be made about the requests generated, and the way the RPL System headquarters processes requests. The first assumption is about the requests. We will assume that the arrival of requests is uniformly distributed over the collection period. In other words, the same number of requests are inprocessed every day (including weekends). This helps make calculations very simple later on.

The next assumption concerns the processing of requests. We will assume that service time is exponential and that service begins on a request when it enters the System (arrives at RPL).

With the above assumptions, we can begin to construct the model. Let us suppose that our data collection period is N days, and that 1/N requests are inprocessed on each day. How many requests will have completed processing T days after the end of the sampling period, given that the average time to process a request is $1/\mu$ days.

For a request inprocessed on the first day, the probability that the time to complete processing is less than or equal to N+T days is

$$p(t_1 \leq N + T) = \int_0^{N+T} \mu e^{-\mu t}\, dt$$

$$= 1\text{-}e^{-\mu(N + T)}$$

For a request inprocessed on the second day, the probability that processing will be finished on or before the Tth day after the end of the sampling period is

$$p(t_2 \leq N + T) = \int_0^{N+T-1} \mu e^{-\mu t}\, dt$$

$$= 1\text{-}e^{-(\mu)(N + T - 1)}$$

For a request inprocessed on the Nth day

$$p(t_N \leq N + T) = 1\text{-}e^{\mu(N+T - (N-1))}$$

Having calculated the individual probabilities for requests inprocessed on each of the N sampling days, we can determine the percent of the requests that will have completed processing T days after the end

of the sampling period. This percentage is the sum of the individual probabilities divided by the sampling period. That is,

$$\text{The percent finished} = \sum_{i=1}^{N} \frac{1}{N}\left(1-e^{-\mu(N+T-(i-1))}\right)$$

$$= 1 - \frac{1}{N} \sum_{i=1}^{N} e^{-\mu(N+T-i+1)}$$

where $1/\mu$ is the average processing time, N is the sampling period in days, and T is the time in days beyond the sampling period.

A computer program was written which calculated the percent of requests finished using RPL's average processing time (14.65 days, from Figure 3) and several values for N and T. The program was compared with a 4 week (28 day) sample (all requests in-processed in the first 28 days of the sampling period). The comparison is in Figure 6. Note that the computer model is slightly optimistic if we wait more than 2 weeks. However, considering the extreme simplicity of the model, it yields reasonable predictions of the percent of requests that are completed.

The sampling period actually chosen for the RPL System was 12 weeks (84 days). Our simple model was run with this sampling period. The results are shown in Table 28. The last day that data was collected was Thursday, 28 October, 52 days after 6 September, the end of the sampling period. Our simple model predicts that we got 99.4% of the requests.

TABLE 28

THE PREDICTED PERCENT OF REQUESTS COMPLETED AS A FUNCTION OF THE NUMBER OF DAYS AFTER THE SAMPLING PERIOD ENDS

Days After 6 September	Percent Finished
7	89.6
14	93.5
21	96.0
28	97.5
35	98.5
42	99.0
49	99.4
56	99.6
63	99.7
70	99.8

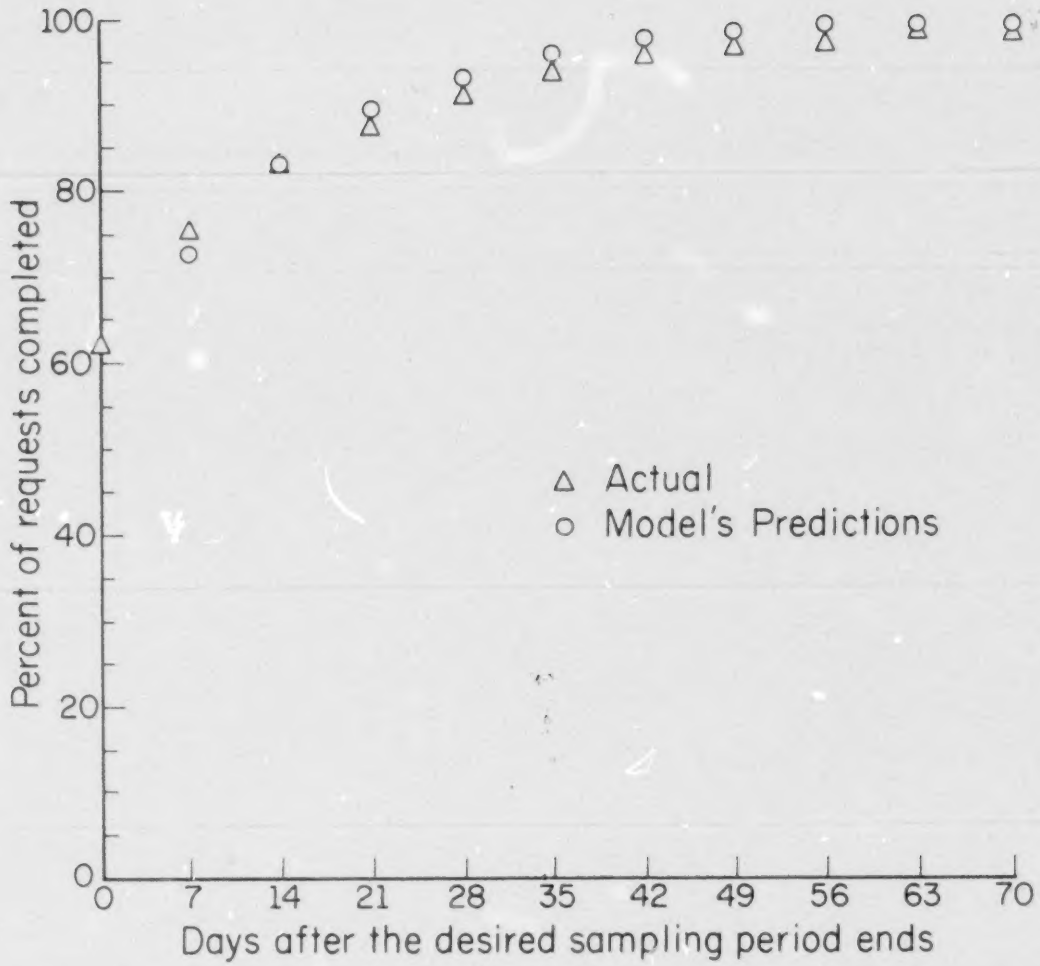


Figure 6. Comparison of Model with Four Weeks of RPL Data

APPENDIX 3

CLASSIFICATION OF REQUESTS

Sandra H. Rouse

Interlibrary loan requests processed by the RPL System between 14 June 1976 and 6 September 1976 were assigned a subject related code. Each subject related code consists of the following three components: confidence code, subject category code, and literature type/requester type code. The confidence code reflects the confidence of the coder in assigning an accurate subject category to a request. The confidence code is a one digit number from 0 to 2, the highest level of confidence being indicated by 0. The subject category code ranges from 01 to 26 and in general reflects the subjects most likely to be represented by requests processed by RPL. Subject categories were generated by using the following information from the request slips: author, title, subject description, call number if available, publisher name, and other codes indicated by the RPL librarians on the slips, such as B - biography, J, Y or JE - juvenile, and P - playing record. If the subject category was not clear from the author, title, call number, and one of the following publishers was identified, - Ace, Ballantine, Dell, Avon, Bantam - the request was coded with the fiction subject category. Call number information was used as a last criterion when all else failed. This seemed reasonable because call number would not be available to RPL librarians routing requests. The 26 subject codes and brief descriptions are indicated at the end of this discussion. Literature

type/requester type codes were assigned based on the following information from the ILL form: 1 - juvenile title, 2 - juvenile subject, 3 - juvenile reference, 4 - adult title, 5 - adult subject, 6 - adult reference, 7 - periodical, and 8 - AV, records/cassettes. Juvenile age groups are defined as school grades through eighth grade, and adults are defined as high school or ninth grade and beyond. If no age group was indicated, adult was assumed. A reference request generally required more specific information than a subject request. For example, the librarian filling a reference request may have to read part of a book instead of relying on title, author, subject heading from the card catalogue.

Subject Code	Description
01	Traveling, movies - vacation suggestions, history/culture of countries, history, facts about movies, movie productions
02	Newspapers - always coded with literature type code of periodical, e.g. 0027
03	Music - includes printed music, recordings/cassettes and may have included music lessons (Dewey 700)
04	Biography, autobiography - frequently coded by RPL librarian with "B" call number (Dewey 900)
05	Education (self-improvement, careers, teaching, psychology, health) - regarding children, teenagers (Dewey 300)
06	Education (self-improvement, careers, teaching, psychology, health) - general adult level (Dewey 300)

Subject Code	Description
07	Society and culture - contemporary commentaries, alternative life styles, ethics, social values, and philosophy (Dewey 100, 300)
08	Religion - seminary oriented literature, conventional religious publications or historical religious publications, if Concordia Seminary indicated as library filling request (Dewey 200)
09	History - reporting, interpreting political/social/economic events associated with a particular time span (Dewey 900)
10	Political science - current events, trends, non-historical accounts, political party orientation, law (Dewey 300)
11	Census - statistics on population, employment, income, etc., particular breakdowns such as region, states, time span (Dewey 300)
12	Athletics, sports - professional/amateur sports, games, physical fitness (Dewey 600, 700)
13	Fiction (Dewey 800)
14	Geneology - family/local history such as cities, counties, family surnames, if Shawnee Library filled request (Dewey 900)

Subject Code	Description
15	Crafts, hobbies, pets, general lifestyle of animals, fine arts, gardening, "how to" information such as start a business, real estate, diet/nutrition (Dewey 600, 700)
16	Repair, maintenance, construction - amateur level (Dewey 900)
17	Food science - scientific level of analysis of food content, toxicity, etc., requested by Stahley Library
18	Manuals, encyclopedias, engineering handbooks, factual data, reference books; used unless other subject categories appeared more appropriate (Dewey 000-099)
19	Non-fiction - cannot place in any of the above categories but may involve literary/scholarly criticism, review, etc. and usually filled by ISL or UOI (Dewey 000-099)
20	Business, economics, mathematics, management - filled by ISL or UOI indicating comparatively advanced level (Dewey 300)
21	Science, natural history, agriculture, chemistry, medicine - filled by ISL or UOI indicating comparatively advanced level (Dewey 500)

Subject Code	Description
22	Sociology, anthropology, social development of man's customs, traditions, psychology - filled by ISL or UOI indicating comparatively advanced level (Dewey 300)
23	Engineering, mechanics, technology - filled by ISL or UOI indicating comparatively advanced level (Dewey 600)
24	Libraries - (Dewey 000-099)
25	Other - have no idea
26	Language, grammar (Dewey 400)